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EVALUATION OF X
SHAWNEE NATIONAL
FOREST WILDLIFE OPENINGS

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FINAL REPORT

W-94-R

# EVALUATION OF SHAWNEE NATIONAL FOREST WILDLIFE OPENINGS

Submitted by
Cooperative Wildlife Research Laboratory, SIU-C

May 14, 1987

Prepared by:
Jesse L Overcash
Jesse L. Overcash, Researcher I
Cooperative Wildlife Research Lab.
Southern Illinois University
Carbondale, IL 62901

and
John L Roseberry
John L. Roseberry, Associate Scientist
Cooperative Wildlife Research Lab.
Southern Illinois University
Carbondale, IL 62901

Supervised by:
John L Roseberry
John L. Roseberry, Associate Scientist
Cooperative Wildlife Research Lab.
Southern Illinois University
Carbondale, IL 62901

Approved by:
W D Klimstra
W. D. Klimstra, Director
Cooperative Wildlife Research Lab.
Southern Illinois University
Carbondale, IL 62901

# FINAL REPORT

STATE OF ILLINOIS W-94-R

SHAWNEE HILLS PROJECT

PROJECT PERIOD: April 1, 1984 through March 30, 1987

STUDY II: Evaluation of Shawnee National Forest Wildlife Openings

Prepared by: Jesse L. Overcash and John L. Roseberry, Cooperative Wildlife Research Laboratory, Southern Illinois University-Carbondale

Need: A substantial amount of time, effort, and money has already been expended to establish and maintain openings in the Shawnee National Forest on the assumption that this program benefits certain forms of wildlife, especially white-tailed deer, wild turkey, and bobwhite. However, the actual and potential contribution of these efforts to the region's wildlife communities had not previously been objectively evaluated, and there was a recognized need to do so.

Objective: To document and measure the use of openings by selected forms of wildlife and correlate this use with management practices and physical characteristics of the openings.

## EXECUTIVE SUMMARY

A companion phase of this project (Study I: Classification, Inventory, and Analysis of Shawnee National Forest Wildlife Openings) has already been completed and reported (Overcash and Roseberry 1986). Study II: Evaluation of Shawnee National Forest Wildlife Openings, reported here, was begun April 1, 1984 and terminated March 30, 1987. It consisted of 2 Jobs: 1) Investigate the Use of Openings by Selected Wildlife Species and 2) Investigate the Impact of Openings on the Distribution and/or Abundance of Selected Wildlife Species.

Two hundred forty maintained openings were selected for detailed study using a stratified random sampling scheme that ensured representation of all forest types within the various natural divisions of the SNF. Transects within each sample opening were established to assess seasonal utilization by white-tailed deer and bobwhite. Local distribution of bobwhite relative to forest openings was evaluated using call count routes established in forested areas with and without openings. Distribution of wild turkeys in relation to openings was investigated by comparing reported turkey sightings per quarter section with the presence or absence of openings. Breeding nongame bird census routes were established at 41 openings and associated forest habitats representing a variety of vegetative situations within the forest. Physical and vegetative data relating to openings and surrounding areas were obtained mainly during Study I.

Maintained openings in the SNF were heavily used by white-tailed deer, with degree and type of use varying seasonally and with surrounding land-use patterns. Total number of trails leading into and out of openings indicated greatest such use in spring and, to a lesser extent, in winter. Foraging in openings was heavy during both spring and summer with winter wheat and red clover favored in spring when available. Red clover was preferred in summer but new growth of woody vegetation was also important. Openings were also used for fawn concealment in summer. Foraging in openings was generally minimal in fall in the absence of cool-season grasses or legumes (domestic or native). However, use of mowed openings, where new growth was stimulated, was extensive.

Size and shape of openings also influenced deer use. Smaller openings contained more beds and trails per unit area than larger openings and were foraged more uniformly. However, deer tended to utilize entire openings regardless of size or shape when preferred forage (red clover, cereal grains) and/or cover were available.

The relative distribution/abundance of bobwhites did not appear to be influenced by presence or absence of maintained openings, either in heavily forested or relatively open habitats. However, quail use of individual openings was documented, especially disturbed openings within 400 m of other non-forested habitat.

Turkey sightings forest-wide were almost 3 times greater than expected in areas that contained 4 or more nearby openings. Turkey use of individual openings was seemingly related to the proximity of permanent water.

Forest openings influenced the relative abundance and species composition of woodland breeding birds with number of species, individuals, and diversity being positively correlated with opening size and representation of woody cover within the opening. However, small (0.1-0.2 ha) openings in mature deciduous forest were apparently not large enough to attract substantial numbers or variety of opening-dependent species. Data also suggested that the present distribution of openings and private lands within the SNF are not affecting the presence of area-sensitive forest interior species.

Data indicate smaller openings would be more intensively utilized by deer and would have less impact on the distribution of woodland breeding songbirds; thus in the event of new construction, openings should be limited to 0.2-0.5 ha and shaped to enhance soil retention, especially if future disturbance is anticipated. However, a more efficient approach

would be to halt further construction of openings. Approximately 1550 openings presently exist within the Forest, but ineffective management in some areas has lessened their importance as critical habitat (i.e. early wild turkey brood habitat). The "more is better" approach to the wildlife opening program obviously has stretched financial resources and has detracted from overall management effectiveness, especially within the Jonesboro and Murphysboro districts. It is felt a reduction of 200-300 openings could ensure increased utilization of remaining openings and free up funds so intensive management for quail, early wild turkey brood range, and white-tailed deer could be accomplished. This reduction is recommended fully realizing that potential exists for decreased deer numbers in the future; however, to assume forest openings are solely responsible for deer population fluctuations in southern Illinois would be a mistake. Changing private land use patterns within inholdings along with harvest management are undoubtedly the major factors affecting white-tailed deer abundance.

Present opening density varies greatly within the Forest. If increased utilization of individual openings is desired, then a density of 1-5 other openings (located 200-600 m apart) within a 1.0 km radius (310 ha) should enhance use of a given opening. Given the patchy nature of the SNF, these openings most likely would not be the only other non-forested habitat within 1.0 km. However, if distribution of deer is to be influenced, 5-10% of the area within the surrounding 1.0 km should be maintained in open habitat. Apparently, large clusters of openings and/or adjacent open habitat attracted deer; probably because of increased availability of foraging and bedding sites. This open habitat could include managed openings, old fields, or right-of-ways within 1.0 km. Private pasture,

hayfields, and/or cropland should not be considered in the percentage of open habitat within 1.0 km because of frequent overgrazing, haying, and fall plowing.

Throughout the Vienna and Elizabethtown districts, where dense opening vegetation is uncommon compared to the Jonesboro District, mowing every 2 years would probably suffice in controlling encroachment of woody growth. Woody vegetation provides forage and cover for deer; thus, complete elimination through herbicide use should be avoided. However, unlike present management and excluding that recommended for domestic legumes, only half of the openings within a given compartment should be mowed each year; thus, mowed openings, which provide valuable late summer and early fall forage to deer, would be present within individual compartments every year.

Priority should be given to delineation and establishment of quail management areas, especially within the Vienna (compartments 29, 36, 94, 95, and 96) and Elizabethtown (compartments 28, 31, 41, 42, and 43) districts and portions of the Murphysboro District (compartments 4, 7, 49, 50, 61, and 63). High densities of openings in conjunction with extensive southern pine plantations and/or those within 400 m of private agriculture could provide valuable feeding, nesting, or roosting habitat.

An intensive management program utilizing discing and burning would be required if the State and Forest Service intend to realize increases in local quail populations solely through the manipulation of public lands. Management for quail and attempts to establish and maintain desirable turkey brood habitat within Jonesboro District openings would be expensive. But, elimination of undesirable or problem openings and less intensive management via mowing and burning of remaining openings would help offset costs associated with intensive efforts.

Several factors must be considered when managing for quail. If winter food is of primary concern, planting of annual cereal grains followed by 1 year abandonment could produce food supplies and desirable bare ground conditions. In small openings, discing should occur throughout, but in larger (>0.4 ha) openings only a portion should be disced every 2 years and the part disced should be alternated. Thus, a portion of an opening would be in food producing condition and the remainder providing nesting habitat.

If a compartment or group of compartments is designated for quail management, not all openings should be in cereal grain production. Some openings providing primarily nesting habitat might be desirable. Upon delineation of quail management areas, remaining openings need to be visited, vegetation assessed, utility determined, and appropriate management identified. Those SNF openings containing a native-warm season grass component (i.e. little bluestem, broom sedge) were judged to be structurally more desirable for turkey brood use than those dominated by perennial and annual forbs. These grasses are also used in nest construction and concealment by quail. If existing opening vegetation is determined desirable and/or a warm-season grass component is present, burning should be used to maintain it. Disturbance should entail only light discing. Small openings should be burned on a 3-year rotation, but larger (1.0 ha) openings should be partially burned creating adjacent feeding and nesting habitats; however, burning an area decreases nesting potential the year of the burn. To offset this, year of burning should be staggered among several openings.

Legume production and maintenance is dependent upon mowing. If maximum legume production is desired, mowing twice a year is recommended.

Deer management should be aimed at providing a variety of vegetation types. Strategically located red clover openings in combination with openings of native vegetation maintained in various stages of early secondary succession (1-4 yrs) through burning or mowing would provide excellent forage and bedding sites for deer.

In instances where woody vegetation detracts from potential wild turkey brood habitat, annual mowing would be required to provide desirable habitat for late summer and fall; this condition was readily evident within the Jonesboro and Murphysboro districts. If protective cover is absent, an unmowed strip at least 5 m wide along the edge of clearings should be left to provide protective cover, foraging sites for young poults, and nesting habitat for hens. Alternating portions of this strip could be mowed from year to year to prevent woody encroachment. This method of mowing openings should be incorporated into present management in the SNF. Currently, entire openings are mowed, and most exhibit no intermediate seral stage between forest and opening, unless located in old fields or young plantations. While complete mowing may be the most cost effective method in very small openings (0.1 ha), it is not desirable for wildlife regardless of opening size.

More intensive management of openings comprised of structurally undesirable vegetation could also be accomplished by discing/plowing openings and seeding with orchard grass. Once established, mowing should occur annually and a light discing every 2 years to remove accumulated duff and maintain a grass/forb vegetation type. Several openings within the Jonesboro District had been seeded to orchard grass and were structurally superior to most others observed. This cool-season grass could be valuable, as compared to fire-dependent warm-season grasses, in areas dominated

by hardwoods (i.e. Jonesboro District) lacking adjacent private hayfields and pastures.

Openings comprised of undesirable vegetation (i.e. honeysuckle, fescue), bisected by gravel roads used for logging or recreation, or habitually abused by campers and/or off-road vehicles should be dropped from future management. If such openings are considered important and/or provide the only open habitat within an area, renovation or mitigation of existing conditions should occur. This might include planting fruit trees or shrubs along one or both sides of the roads; a practice that would provide wildlife food and cover as well as reduce opportunities for poaching from vehicles.

Establishment of legumes in fescue openings should not be attempted without complete elimination of this grass; discing in the absence of roundup application did not prevent fescue from dominating openings 1 year post disturbance. Plowing may be the only mechanical treatment successful in shifting dominance in old fields to annual and eventually perennial forbs.

The SNF opening management program is valuable to a variety of wildlife species, and its importance as a desirable habitat component should not be underestimated. Overgrazed pastures, frequently cut hayfields, fields that are fall plowed, and/or clearcuts cannot be considered comparable habitat to that provided by maintained openings. Also, hunters can identify them and actually see that an effort is being made to enhance hunting opportunities. Even though providing quality habitat for game species is the primary purpose for opening maintenance, nongame species also benefit.

Beyond their importance to wildlife, openings maintained in areas providing views of unusual rock formations, scenic areas, and/or old growth forest are esthetically pleasing. A relatively large number of openings are dominated by, or contain remnants of, native warm-season grasses such as little bluestem, big bluestem, and Indian grass, often associated with various prairie forbs. These are most prevalent in the Shawnee Hills and Cretaceous Hills divisions of the Vienna and Elizabethtown districts, and in the Southern Till Plain portion of the Murphysboro District near Lake Kinkaid. Such plant communities are not only esthetically pleasing, but are the remnants of local communities. Several openings within the Cretaceous Hills exhibited flora characteristic of mesic "barren" sites, such openings should be maintained because of their flora content. With advancing secondary succession, lack of burning, and/or intensive agricultural practices, these communities cannot be expected to maintain themselves. Such sites should be identified and maintained through appropriate management strategies; their number could be substantially increased by controlled burning. Their destruction for whatever reason cannot be tolerated as management is inexpensive and quality habitat is provided.

## INTRODUCTION

The concept of edge and its benefit to selected species has had a profound impact upon wildlife management. Extensive homogenous timber stands of low diversity are often deficient in 1 or more habitat components essential for maximum wildlife productivity. Forest openings and their resulting edges are accepted by most forest wildlife biologists as beneficial, especially for game species.

Edminster (1935) noted little wildlife use of the interior of large conifer stands, and Gray and Hermal (1939) considered open habitats in large forested areas to be beneficial to game. Smith (1958), Bailey and Alexander (1960), and Lay (1964) concluded that large plantations of conifers should be interspersed with openings if production of game was an important consideration. Other studies have documented the influence of openings on the distribution and abundance of selected wildlife species (McGinnes and Ripley 1962, Larson 1967, McCaffery and Creed 1969, Wunz 1979, McCaffery et al. 1981). Open areas are an important component of wild turkey (Meleagris gallopavo) habitat (Stoddard 1936, Lewis 1964, Holbrook and Lewis 1967, Bailey and Rinell 1967, Hillestad and Speake 1970, Speake et al. 1975) and more recent studies have identified clearings (pastures, old fields, forest openings) as important brood rearing habitat (Hamrick and Davis 1972, Martin and McGinnes 1975, Hurst and Stringer 1975, Blackburn et al. 1975, Pack et al. 1980, Healy and Nenno 1983, Healy 1985). White-tailed deer (Odocoileus virginianus) activity in hardwoods of northern Wisconsin was 3 times greater in areas with openings than those without openings (McCaffery and Creed 1969). In addition, ruffed grouse (Bonasa umbellus), and bobwhite (Colinus virginianus) as

well as many nongame species benefited from openings (McCaffery et al. 1981).

In 1950, the U.S. Forest Service and the Illinois Department of Conservation entered into a Memorandum of Understanding to cooperate in wildlife management in the Shawnee National Forest (SNF); in 1956, Pittman-Robertson funds were designated for use to establish and maintain openings and water holes for wildlife.

Approximately 1,550 maintained wildlife openings representing over 1,400 hectares presently exist within the SNF. Until recently, the Illinois Department of Conservation (IDOC) managed about 85 of these for upland game through establishment of cereal grain food plots. Remaining openings are maintained by the Forest Service through periodic treatment including establishment of tame legumes and grasses in openings containing undesirable vegetation, burning, mowing, and herbicide applications.

To enhance the contribution and credibility of the opening management program in the SNF, a two phase project was initiated to collect and synthesize information about openings and their management (Overcash and Roseberry 1986) and to evaluate their importance to white-tailed deer, wild turkey, bobwhite, and songbirds. This study represents the second phase of that project. Objectives were to:

1). Investigate utilization of openings by white-tailed deer, and bobwhite quail,

2). determine the impact of openings on the distribution and/or relative abundance of white-tailed deer, bobwhite quail, wild turkey, and nongame breeding songbirds,

3). determine how the vegetational and physical characteristics of openings affected utilization by white-tailed deer and bobwhite, and

4). make recommendations for future management.

## STUDY AREA

The Shawnee National Forest, located in extreme southern Illinois, represents a discontinuous and diverse patchwork of timbered areas and oldfields interspersed with private lands which exhibit a variety of land-use types. The Forest consists of 105,908 hectares representing 31% of the area within the SNF purchase boundary (Figure 1) (U.S. Forest Service 1985). A complete description of the SNF and associated physiographic regions of southern Illinois is found in Study I (Overcash and Roseberry 1986).

## METHODS

### Wildlife Utilization of Openings

Two hundred forty maintained openings were selected for detailed study. Openings were randomly chosen using a stratification scheme that ensured representation of each forest type within the various natural divisions of the SNF. Physical characteristics and vegetation structure (Table 1) of sampled openings were obtained during this study and a separate but related investigation designed to inventory, classify and describe managed openings within the SNF (Overcash and Roseberry 1986). Methodologies were described in the latter report.

Transects were established within each sample opening to assess utilization by white-tailed deer and bobwhite. Transects were randomly

Figure 1. Property ownership within the purchase boundary of the Shawnee National Forest.

SHAWNEE NATIONAL FOREST

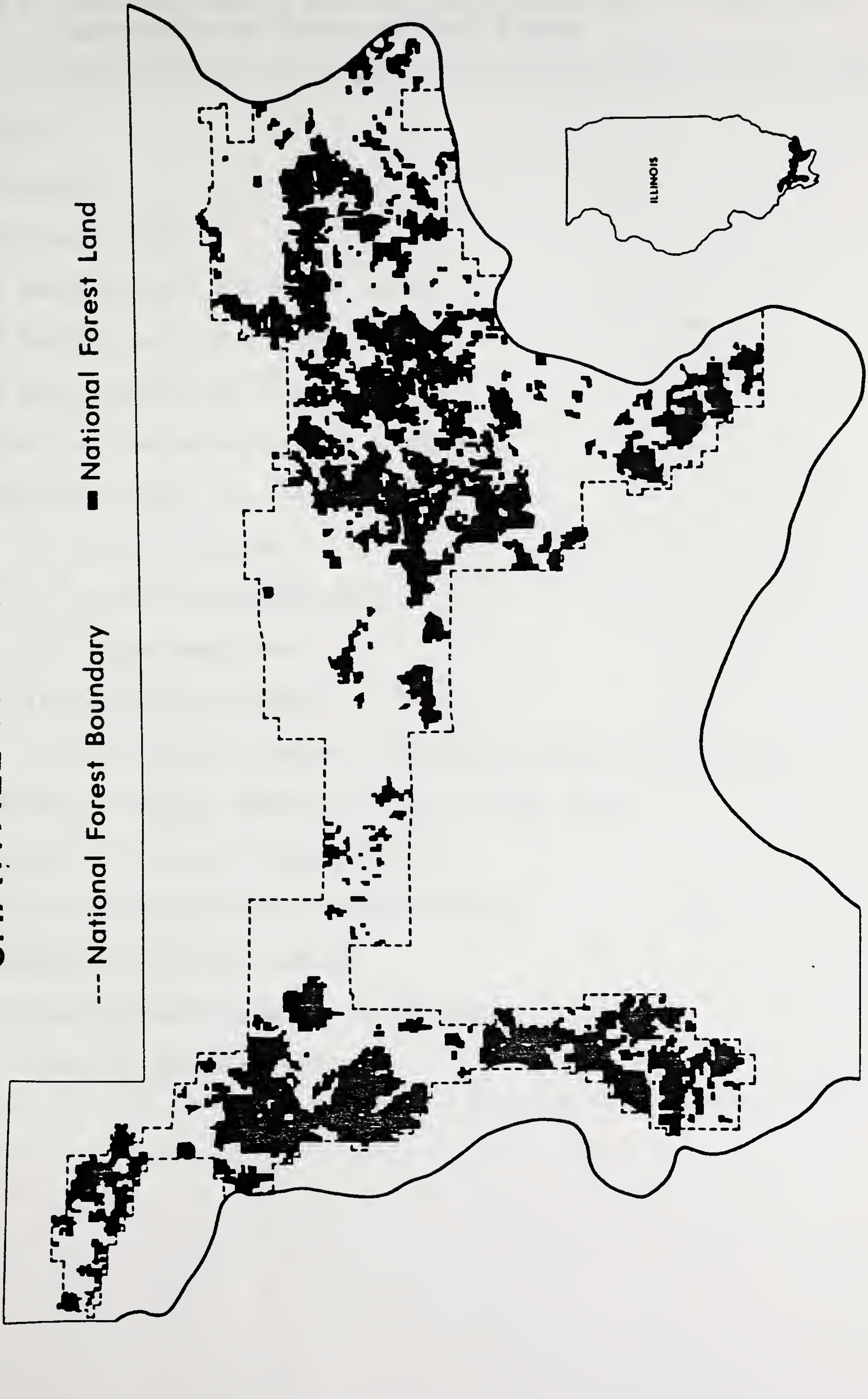


Table 1. Variables used in assessing white-tailed deer utilization of openings in the Shawnee National Forest.

1. Size
2. Perimeter
3. Vegetation type
4. % woody growth < 2 m within opening
5. % woody growth > 2 m within opening
6. % edge comprised of honeysuckle
7. Date and type of most recent treatment
8. Surrounding land use within a 1.0 km radius
    a) percent cropland
    b) percent pasture/hayfield
    c) percent deciduous
    d) percent coniferous
    e) percent other openings (oldfields, managed openings, etc.)
9. Number of managed openings within a 1.0 km radius
10. Distance to nearest managed opening
11. Distance to nearest non-forested habitat
12. Distance to nearest cropland
13. Distance to nearest pasture or hayfield
14. Distance to permanent water

selected from a series of successively numbered imaginary lines 4 m apart running the width of the opening. The width of each transect sampled was 2 or 4 m depending on the index being obtained. The number of transects established in each opening was determined as follows:

$$\frac{\text{estimated area } (\text{m}^2) \text{ of opening} \times 0.2}{\text{transect length } (\text{m}) \times 2}$$

This procedure gave the number of 2 m wide transects required to sample 20% of the opening (indices utilizing a 4 m wide transects effected a 40% sampling of individual openings).

Utilization data were obtained from openings 4 times annually in mid January-February, April-early May, June-early July, and October-early November. One hundred forty openings in the eastern portion of the Forest were sampled in 1985 and 100 openings in the western portion were sampled in 1986.

White-tailed deer.--Several indices were obtained to assess utilization of openings by white-tailed deer. Deer beds within 2 m of either side of the randomly selected transects were recorded during each of the 4 seasonal sampling periods. Distance from bedsite to nearest edge was also recorded. Deer foraging was monitored during spring, summer, and fall by examining 1 $\text{m}^2$ plots established every 10 steps along each transect. Incidence of foraging, species foraged, and distance to nearest edge were recorded. The final index of deer utilization was obtained by counting the number of trails leading into each opening and recording the relative use of each (light, medium, heavy). The effect of season, region, and physical features on deer use of individual openings was investigated using simple and multiple correlation analysis, ANOVA, and Duncan's Multiple Range Test.

Bobwhite.--Use of openings by quail during fall and winter was assessed by counting covey roosts within 1 m either side of the sampling transects. Nests and/or flushed birds were recorded during spring and summer. Whistling cocks within or near openings were also noted.

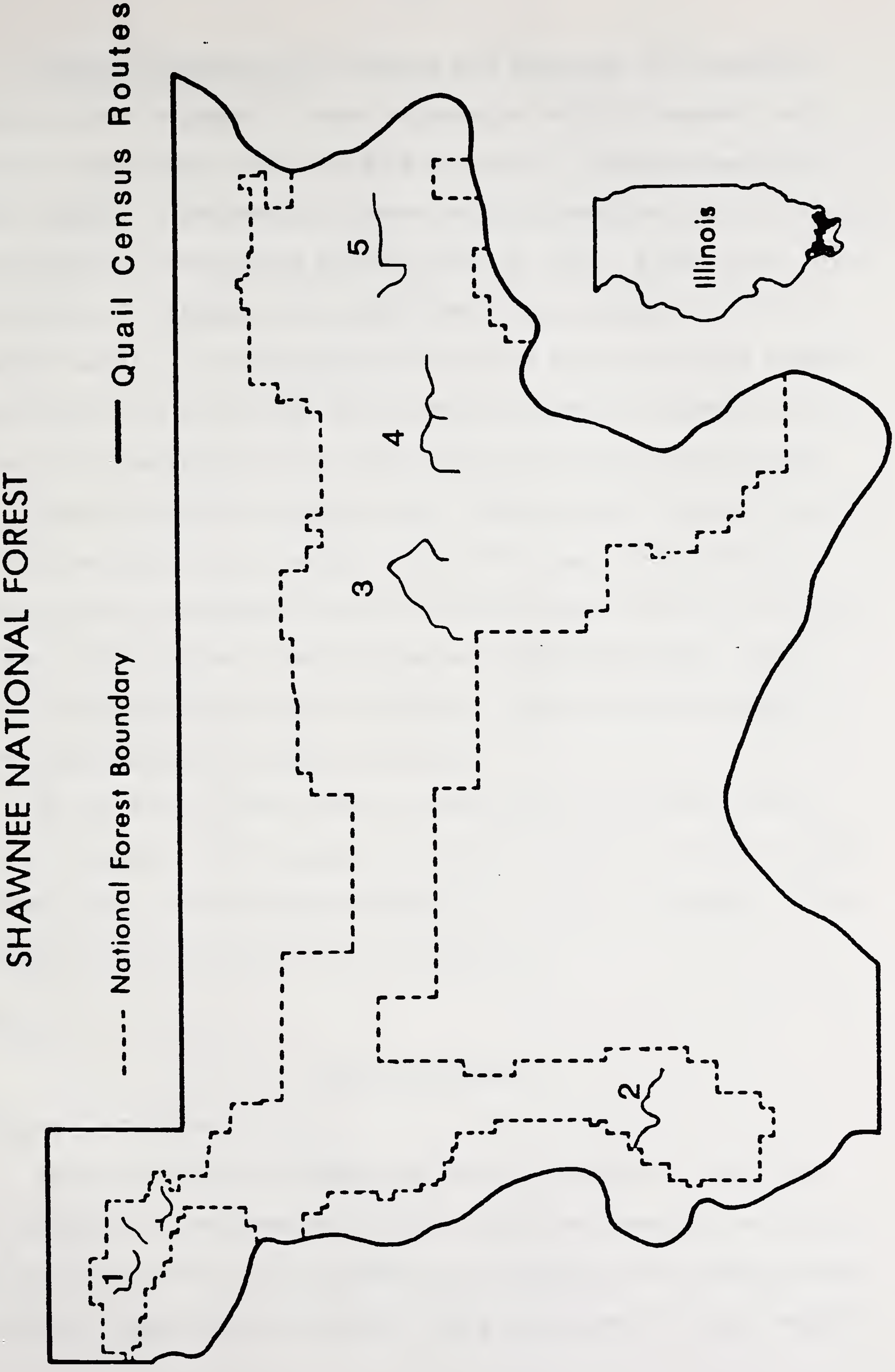
## Influence of Openings on Species Distribution and Abundance

Bobwhite.--Distribution of quail relative to forest openings was assessed using whistling cock counts (Bennitt 1951, Rosene 1957). Five census routes were established representing heavily wooded and relatively open forest habitats with and without maintained openings (Figure 2). Each route consisted of 16-20 listening stations approximately 1 km apart. Routes were driven 4 times annually during June 1985 and 1986 and the total number of calls heard during 2 minute stops at each station was recorded. Surrounding habitat, including number of forest openings within 0.5 and 1.0 km of each listening station was determined from aerial photographs.

Preliminary analysis revealed that the amount of surrounding coniferous and deciduous habitat greatly influenced call counts. Therefore, data were analyzed separately for areas <> 75% forested. Student's t-test was used to determine if mean call counts differed for stations with and without openings within a 0.5 km radius.

Wild Turkey.--Distribution of eastern wild turkeys relative to forest openings was investigated using sightings by successful deer hunters in 1984, U.S. Forest Service personnel and other cooperators as well as known flock locations. Sightings were plotted by quarter section on Forest Service Sportsman's Maps. Observed and expected frequencies of turkey sightings in relation to forest openings within quarter sections were compared using Chi square goodness-of-fit tests.

Figure 2. Location of quail census routes conducted in the Shawnee National Forest.


SHAWNEE NATIONAL FOREST
National Forest Boundary
Quail Census Routes
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Illinois

Breeding nongame birds.--Censuses were conducted at 41 openings to assess the influence of forest openings on relative abundance and species composition of woodland breeding birds. Twenty-one openings were selected in predominately mature deciduous woods and 20 in or partially surrounded by southern pine stands (25-50 yrs. old). A bird census strip, consisting of 5 segments, was established at each opening. The first segment was in the opening itself, the other 4 represented 25 m segments beginning at the forest edge and extending away from the opening. Three counts were conducted at each opening; all were sampled during 30 May - 17 June 1985 and 30 during June 1986. Transects were walked (20 minutes total time) beginning at sunrise. Each bird visually and/or aurally detected was recorded on a plot map as being in one of the five transect segments which had been previously marked with flagging tape. Birds beyond 75 m of either side of the transect and/or not within sampled pine stands were not included in analysis.

Mean number of species and individuals were calculated for each transect segment. Also computed were species diversity (H') and species richness (S). Diversity was calculated as $H' = -p_i \ln p_i$ where p = the proportion of individuals in the $i^{th}$species.

## RESULTS

### White-tailed Deer

#### Seasonal Differences

White-tailed deer utilization of openings varied by season (Table 2, Appendix B). Mean number of trails leading into openings was highest in spring and winter. Trail formation was enhanced during these periods as dormant vegetation, moist ground, and group movement by deer combined

Table 2. White-tailed deer utilization of openings by season, Shawnee National Forest.

| INDEX | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total trails | | | Total beds | | | Percent plots foraged[1] | | |
| Season | N | $\bar{X}$ | Season | N | $\bar{X}$ | Season | N | $\bar{X}$ |
| Spring | 240 | 3.4 a* | Winter | 240 | 1.1 a | Summer | 215 | 12.5 a |
| Winter | 240 | 3.0 a | Fall | 233 | 0.7 b | Fall | 233 | 12.2 a |
| Fall | 233 | 2.1 b | Summer | 215 | 0.6 b | Spring | 240 | 8.8 b |
| Summer | 215 | 1.8 b | Spring | 240 | 0.2 c | | | |

*Means with same letter not significantly different ($p>0.05$).

[1] Not measured in winter.

to make trails prominent. Approximately 50% of trails during these seasons had light use, 45% medium, and 5% heavy. In contrast, summer and fall vegetative conditions hampered potential trail definition. During summer, 75% of trails showed light use, 23% medium and 1% heavy. In fall, 57% received light use, 38% medium, and 5% heavy. Increased late winter and spring trail use was expected as greenup associated with these periods provided valuable forage just as deer emerged from the winter months.

Deer beds in openings were most common in winter, probably a result of lack of suitable cover for bedding and concealment throughout other habitat types, and potential forage in the form of basal rosettes of several herbaceous species. Summer use often consisted of isolated fawn bed sites and/or an associated adult.

Foraging of sampled plots revealed that opening vegetation was an important food source for deer in summer and fall. Foraging during the latter season was enhanced in openings which were mowed in late summer or early fall. Without this treatment, the incidence of fall foraging diminished rapidly and was less prevalent than in spring. Most herbaceous plants had matured and/or died by the fall sampling period, exceptions included domesticated and native legumes as well as cool-season grasses.

## Regional differences

Openings were grouped into 5 geographic regions (Figure 3) for analysis based on differences in physiography, surrounding land use patterns (Appendix A), forest composition, mean values for measured indices (Table 3, Appendix C) and regional differences in deer densities as indicated by county hunter success rates. Regardless of season or region, however, few openings lacked sign of deer use or movement.

Figure 3. Regions delineated for analysis of white-tailed deer utilization of forest openings, Shawnee National Forest.

SHAWNEE NATIONAL FOREST

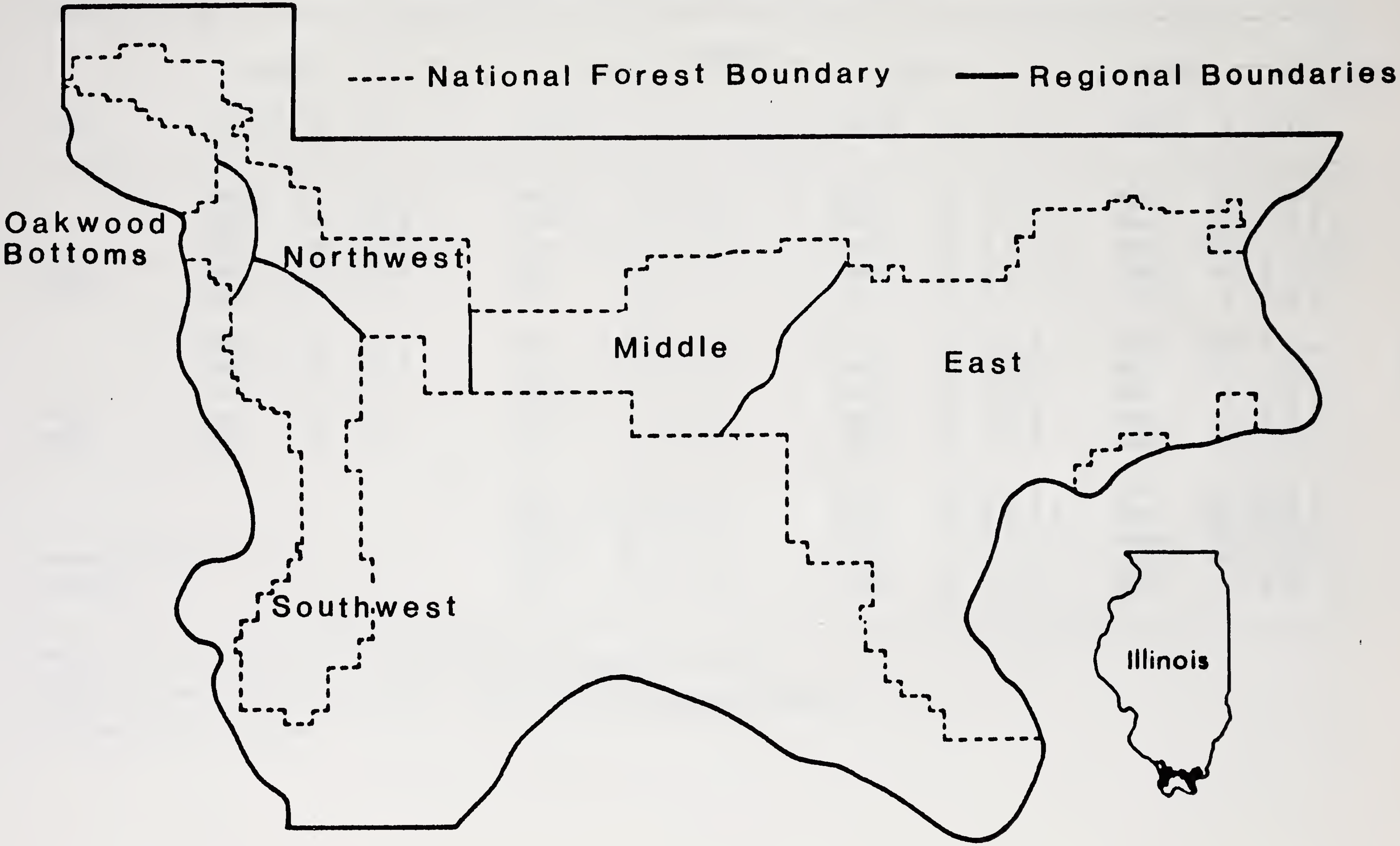

Table 3. White-tailed deer seasonal utilization of openings by region[1] of the Shawnee National Forest.

| | Season | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Spring | | | Summer | | | Fall | | |
| Index | Region | N | $\bar{X}$ | Region | N | $\bar{X}$ | Region | N | $\bar{X}$ | Region | N | $\bar{X}$ |
| Total Trails | NWest | 52 | 4.5 a* | NWest | 53 | 6.4 a | MID | 28 | 2.6 a | MID | 30 | 3.0 a |
| | SWest | 46 | 3.5 a b | SWest | 45 | 3.7 b | NWest | 53 | 2.2 a b | NWest | 52 | 2.4 a b |
| | MID | 30 | 2.7 c b | East | 103 | 2.3 b c | East | 79 | 1.6 c b | East | 102 | 2.2 a b |
| | Oak | 9 | 2.6 c b | Oak | 9 | 2.2 b c | SWest | 46 | 1.2 c d | SWest | 44 | 1.3 c b |
| | East | 103 | 2.2 c | MID | 30 | 2.0 c | Oak | 9 | 0.3 d | Oak | 5 | 0.8 c |
| Total Beds | NWest | 52 | 3.2 a | MID | 30 | 0.3 a | MID | 28 | 1.4 a | East | 102 | 0.9 a |
| | SWest | 46 | 1.8 b | East | 103 | 0.2 a | East | 79 | 0.7 b | MID | 30 | 0.9 a |
| | Oak | 9 | 0.7 c | NWest | 53 | 0.2 a | NWest | 53 | 0.6 b | Oak | 5 | 0.6 a |
| | East | 103 | 0.0 c | SWest | 45 | 0.1 a | Oak | 9 | 0.3 b | NWest | 52 | 0.5 a |
| | MID | 30 | 0.0 c | Oak | 9 | 0.0 a | SWest | 46 | 0.0 b | SWest | 44 | 0.1 a |
| Percent plots foraged[2] | | | | MID | 30 | 13.5 a | MID | 28 | 18.5 a | MID | 30 | 30.3 a |
| | | | | East | 103 | 12.8 a | East | 79 | 15.4 a b | East | 102 | 12.3 b |
| | | | | NWest | 53 | 5.1 b | NWest | 53 | 10.2 c b | NWest | 52 | 10.8 b |
| | | | | SWest | 45 | 2.3 b | Oak | 9 | 7.5 c | SWest | 44 | 2.5 b c |
| | | | | Oak | 9 | 1.5 b | SWest | 46 | 7.3 c | Oak | 5 | 0.0 c |

*Means with same letter not significantly different ($p>0.05$).

[1] NWest=Northwest, SWest=Southwest, MID=Middle, Oak=Oakwood bottoms.

[2] Not measured in winter.

The northwest region, entirely within Jackson County, was considered superior habitat for deer; total trails leading into openings supported this belief as did the high hunter success rate for Jackson County (Kouba 1986).

The southwest region, composed primarily of the steep ravine narrow ridge top topography associated with the Ozark Hills, contained many openings surrounded almost entirely by oak-hickory forest. Thus, opening utilization as indicated by trails was highest when potential forage appeared in late winter and spring.

The middle region was composed primarily of a few scattered Forest Service compartments and associated openings surrounded or bordered by private land. Many of these openings were planted partially or totally to cereal grains and winter wheat by IDOC personnel during this study. Because of this, total trails and percent plots foraged in fall were highest in this region.

The Oakwood bottoms region contained only 9 openings located in the bottomland hardwood forest habitat of the Oakwood Bottoms Greentree Reservoir and the Big Muddy River floodplain. Trails indicated these openings were being utilized as extensively in the winter and spring as openings found in the east and middle regions.

The east region encompassed a large portion of the Forest including all openings east of Illinois route 45 between Harrisburg and Vienna. A substantial pine component surrounding many openings justified the delineation of this region which was thought to contain less desirable deer habitat than the northwest region. The relatively few trials intersecting openings and the low hunter success rate for Pope and Hardin counties supported this assumption.

## Opening characteristics

Size.--For analytical purposes, openings were grouped into 4 size classes: 0.1-0.2, 0.3-0.5, 0.6-0.9, and $\geq$ 1.0 ha. Number of deer trails leading into individual openings was positively correlated with size. This trend was evident in the east, middle, and northwest regions throughout all seasons (Tables 4-6, Appendices D1-D3). The largest opening in the Oakwood bottoms region had a higher mean trail count during winter, spring, and fall (Table 7, Appendix D4), and larger openings in the southwest region had higher mean trail counts in winter and summer, with openings 0.3-0.9 ha containing more in spring and fall (Table 8, Appendix D5).

One would expect larger openings to contain more trails because of increased contact with surrounding forest and, indeed, this was the case. However, smallest openings (0.1-0.2 ha) contained more trails per unit area than other size classes. This trend was evident in east, middle, northwest, and southwest regions during all seasons (Tables 4, 5, 6 and 8).

Mean number of beds was positively related to absolute opening size in the east region during all seasons; but, this trend was not evident in other regions or seasons (Tables 4-8). Also, and possibly more important, smaller (0.1-0.2) to midsize (0.3-0.5 ha) openings contained more beds per unit area than larger openings.

Affect of opening size on foraging varied by region and season; however, there was no significant difference in mean percent foraging between opening size classes regardless of region or season. In the northwest, smaller openings received relatively greater foraging than larger openings spring thru fall (Table 6). This region contained many

Table 4. White-tailed deer seasonal utilization of openings by size (ha) class, east region Shawnee National Forest.

| | SEASON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Spring | | | Summer | | | Fall | | |
| Index | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ |
| Total trails | ≥1.0 | 16 | 3.3 a* | ≥1.0 | 16 | 3.1 a | ≥1.0 | 12 | 2.7 a | ≥1.0 | 16 | 3.8 a |
| | .6-.9 | 28 | 2.5 a c | .6-.9 | 28 | 2.4 a b | .6-.9 | 18 | 1.8 a c | .6-.9 | 27 | 2.1 b |
| | .3-.5 | 47 | 1.8 b c | .3-.5 | 47 | 2.3 a b | .3-.5 | 40 | 1.4 b c | .3-.5 | 47 | 1.8 b |
| | .1-.2 | 12 | 1.3 b | .1-.2 | 12 | 1.5 b | .1-.2 | 9 | 0.8 b | .1-.2 | 12 | 1.4 b |
| Trails per unit area | .1-.2 | 12 | 7.1 a | .1-.2 | 12 | 7.9 a | .1-.2 | 9 | 4.4 a | .1-.2 | 12 | 8.8 a |
| | .3-.5 | 47 | 4.8 a b | .3-.5 | 47 | 6.0 a c | .3-.5 | 40 | 3.7 a b | .3-.5 | 47 | 4.8 b |
| | .6-.9 | 28 | 3.7 b | .6-.9 | 28 | 3.5 b c | .6-.9 | 18 | 2.6 a b | ≥1.0 | 16 | 3.3 b |
| | ≥1.0 | 16 | 2.8 b | ≥1.0 | 16 | 2.6 b | ≥1.0 | 12 | 2.4 b | .6-.9 | 27 | 3.0 b |
| Total beds | ≥1.0 | 16 | 0.2 a | ≥1.0 | 16 | 0.4 a | ≥1.0 | 12 | 0.9 a | ≥1.0 | 16 | 1.8 a |
| | .6-.9 | 28 | 0.0 a | .6-.9 | 28 | 0.2 a | .3-.5 | 40 | 0.8 a | .6-.9 | 27 | 1.1 a b |
| | .3-.5 | 47 | 0.0 a | .3-.5 | 47 | 0.2 a | .6-.9 | 18 | 0.6 a | .3-.5 | 47 | 0.8 a b |
| | .1-.2 | 12 | 0.0 a | .1-.2 | 12 | 0.1 a | .1-.2 | 9 | 0.2 a | .1-.2 | 12 | 0.3 b |
| Beds per unit area | ≥1.0 | 16 | 0.2 a | .3-.5 | 47 | 0.6 a | .3-.5 | 40 | 2.0 a | .3-.5 | 47 | 1.9 a |
| | .6-.9 | 28 | 0.1 a | .1-.2 | 12 | 0.4 a | .1-.2 | 9 | 1.1 a | .6-.9 | 27 | 1.5 a |
| | .3-.5 | 47 | 0.0 a | ≥1.0 | 16 | 0.4 a | ≥1.0 | 12 | 0.8 a | ≥1.0 | 16 | 1.5 a |
| | .1-.2 | 12 | 0.0 a | .6-.9 | 28 | 0.3 a | .6-.9 | 18 | 0.8 a | .1-.2 | 12 | 1.3 a |
| Percent plots foraged[1] | | | | .1-.2 | 12 | 14.1 a | ≥1.0 | 12 | 19.7 a | ≥1.0 | 16 | 13.7 a |
| | | | | .3-.5 | 47 | 13.9 a | .3-.5 | 40 | 16.3 a | .3-.5 | 47 | 12.7 a |
| | | | | .6-.9 | 28 | 11.3 a | .6-.9 | 18 | 12.2 a | .1-.2 | 12 | 11.8 a |
| | | | | ≥1.0 | 16 | 11.2 a | .1-.2 | 9 | 12.1 a | .6-.9 | 27 | 10.9 a |

*Means with same letter not significantly different ($p>0.05$).

[1] Not measured in winter.

Table 5. White-tailed deer seasonal utilization of openings by size (ha) class, middle region Shawnee National Forest.

| | SEASON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Spring | | | Summer | | | Fall | | |
| Index | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ |
| Total trails | ≥1.0 | 2 | 4.0 a* | ≥1.0 | 2 | 2.5 a | ≥1.0 | 2 | 5.5 a | ≥1.0 | 2 | 9.0 a |
| | .3-.5 | 14 | 2.9 a | .3-.5 | 14 | 2.3 a | .6-.9 | 3 | 3.0 b | .3-.5 | 14 | 3.1 b |
| | .1-.2 | 11 | 2.6 a | .6-.9 | 3 | 1.7 a | .3-.5 | 13 | 2.7 b | .1-.2 | 11 | 2.1 b |
| | .6-.9 | 3 | 1.0 a | .1-.2 | 11 | 1.6 a | .1-.2 | 10 | 1.9 b | .6-.9 | 3 | 1.3 b |
| Trails per unit area | .1-.2 | 11 | 13.6 a | .1-.2 | 11 | 8.6 a | .1-.2 | 10 | 10.0 a | .1-.2 | 11 | 11.8 a |
| | .3-.5 | 14 | 8.0 a b | .3-.5 | 14 | 6.2 a | .3-.5 | 13 | 6.8 a | .3-.5 | 14 | 8.0 a |
| | ≥1.0 | 2 | 2.9 a b | ≥1.0 | 2 | 2.1 a | ≥1.0 | 2 | 3.9 a | ≥1.0 | 2 | 5.7 a |
| | .6-.9 | 3 | 1.3 b | .6-.9 | 3 | 2.1 a | .6-.9 | 3 | 3.9 a | .6-.9 | 3 | 1.8 a |
| Total beds | .3-.5 | 14 | 0.1 a | ≥1.0 | 2 | 3.8 a | ≥1.0 | 2 | 4.5 a | ≥1.0 | 2 | 4.0 a |
| | .1-.2 | 11 | 0.0 a | .1-.2 | 11 | 0.2 b | .1-.2 | 10 | 1.5 b | .3-.5 | 14 | 1.0 b |
| | .6-.9 | 3 | 0.0 a | .3-.5 | 14 | 0.1 b | .6-.9 | 3 | 1.3 b | .1-.2 | 11 | 0.5 b |
| | ≥1.0 | 2 | 0.0 a | .6-.9 | 3 | 0.0 b | .3-.5 | 13 | 0.8 b | .6-.9 | 3 | 0.0 b |
| Beds per unit area | .3-.5 | 14 | 0.2 a | ≥1.0 | 2 | 2.1 a | .1-.2 | 10 | 8.0 a | .1-.2 | 11 | 2.7 a |
| | .1-.2 | 11 | 0.0 a | .1-.2 | 11 | 0.9 a | ≥1.0 | 2 | 3.0 a | .3-.5 | 14 | 2.6 a |
| | .6-.9 | 3 | 0.0 a | .3-.5 | 14 | 0.1 a | .3-.5 | 13 | 2.0 a | ≥1.0 | 2 | 2.6 a |
| | ≥1.0 | 2 | 0.0 a | .6-.9 | 3 | 0.0 a | .6-.9 | 3 | 2.0 a | .6-.9 | 3 | 0.0 a |
| Percent plots foraged[1] | | | | ≥1.0 | 2 | 18.1 a | .1-.2 | 10 | 22.0 a | .1-.2 | 11 | 41.1 a |
| | | | | .3-.5 | 14 | 14.7 a | ≥1.0 | 2 | 21.9 a | .3-.5 | 14 | 26.0 a |
| | | | | .6-.9 | 3 | 12.3 a | .6-.9 | 3 | 16.5 a | ≥1.0 | 2 | 20.3 a |
| | | | | .1-.2 | 11 | 11.4 a | .3-.5 | 13 | 15.6 a | .6-.9 | 3 | 17.8 a |

*Means with same letter not significantly different ($p>0.05$).

[1] Not measured in winter.

Table 6. White-tailed deer seasonal utilization of openings by size (ha) class, northwest region Shawnee National Forest.

| | SEASON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Spring | | | Summer | | | Fall | | |
| Index | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ |
| Total trails | .6-.9 | 4 | 6.8 a* | ≥1.0 | 1 | 14.0 a | ≥1.0 | 1 | 3.0 a | ≥1.0 | 1 | 4.0 a |
| | ≥1.0 | 1 | 5.0 a | .6-.9 | 4 | 9.3 a b | .3-.5 | 29 | 2.6 a | .6-.9 | 4 | 3.0 a |
| | .3-.5 | 28 | 4.8 a | .3-.5 | 29 | 7.1 b | .6-.9 | 4 | 1.8 a | .3-.5 | 28 | 2.6 a |
| | .1-.2 | 19 | 3.5 a | .1-.2 | 19 | 4.4 b | .1-.2 | 19 | 1.6 a | .1-.2 | 19 | 1.8 a |
| Trails per unit area | .1-.2 | 19 | 18.9 a | .1-.2 | 19 | 23.9 a | .1-.2 | 19 | 9.2 a | .1-.2 | 19 | 10.8 a |
| | .3-.5 | 28 | 12.6 a | .3-.5 | 29 | 19.0 a | .3-.5 | 29 | 6.9 a | .3-.5 | 28 | 6.9 a |
| | .6-.9 | 4 | 9.2 a | ≥1.0 | 1 | 14.0 a | ≥1.0 | 1 | 3.0 a | .6-.9 | 4 | 4.2 a |
| | ≥1.0 | 1 | 5.0 a | .6-.9 | 4 | 12.4 a | .6-.9 | 4 | 2.5 a | ≥1.0 | 1 | 4.0 a |
| Total beds | .6-.9 | 4 | 9.0 a | .6-.9 | 4 | 1.5 a | .1-.2 | 19 | 0.7 a | .6-.9 | 4 | 1.0 a |
| | .3-.5 | 28 | 3.3 b | .1-.2 | 19 | 0.2 b | .3-.5 | 29 | 0.6 a | .3-.5 | 28 | 0.7 a |
| | .1-.2 | 19 | 2.1 b | .3-.5 | 29 | 0.0 b | .6-.9 | 4 | 0.3 a | .1-.2 | 19 | 0.1 a |
| | ≥1.0 | 1 | 0.0 b | ≥1.0 | 1 | 0.0 b | ≥1.0 | 1 | 0.0 a | ≥1.0 | 1 | 0.0 a |
| Beds per unit area | .6-.9 | 4 | 12.0 a | .6-.9 | 4 | 2.1 a | .1-.2 | 19 | 4.2 a | .3-.5 | 28 | 2.1 a |
| | .1-.2 | 19 | 11.1 a | .1-.2 | 19 | 0.8 a | .3-.5 | 29 | 1.7 a | .6-.9 | 4 | 1.3 a |
| | .3-.5 | 28 | 8.8 a | .3-.5 | 29 | 0.1 a | .6-.9 | 4 | 0.3 a | .1-.2 | 19 | 0.5 a |
| | ≥1.0 | 1 | 0.0 a | ≥1.0 | 1 | 0.0 a | ≥1.0 | 1 | 0.0 a | ≥1.0 | 1 | 0.0 a |
| Percent plots foraged[1] | | | | .1-.2 | 19 | 6.0 a | .1-.2 | 19 | 18.4 a | .1-.2 | 19 | 17.6 a |
| | | | | .3-.5 | 29 | 4.8 a | .6-.9 | 4 | 6.2 a | .3-.5 | 28 | 7.8 a |
| | | | | .6-.9 | 4 | 4.8 a | .3-.5 | 29 | 5.7 a | ≥1.0 | 1 | 2.4 a |
| | | | | ≥1.0 | 1 | 0.0 a | ≥1.0 | 1 | 1.2 a | .6-.9 | 4 | 1.4 a |

*Means with same letter not significantly different ($p>0.05$).

[1] Not measured in winter.

Table 7. White-tailed deer seasonal utilization of openings by size (ha) class, oakwood bottoms region Shawnee National Forest.

| | SEASON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Spring | | | Summer | | | Fall | | |
| Index | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ |
| Total trails | .3-.5 | 1 | 6.0 a* | .3-.5 | 1 | 6.0 a | .1-.2 | 8 | 0.4 a | .3-.5 | 1 | 1.0 a |
| | .1-.2 | 8 | 2.1 a | .1-.2 | 8 | 1.8 b | .3-.5 | 1 | 0.0 a | .1-.2 | 4 | 0.8 a |
| Trails per unit area | .3-.5 | 1 | 20.0 a | .3-.5 | 1 | 20.0 a | .1-.2 | 8 | 1.9 a | .1-.2 | 4 | 3.8 a |
| | .1-.2 | 8 | 13.1 a | .1-.2 | 8 | 11.3 b | .3-.5 | 1 | 0.0 a | .3-.5 | 1 | 3.3 a |
| Total beds | .3-.5 | 1 | 1.0 a | .1-.2 | 8 | 0.0 a | .1-.2 | 8 | 0.4 a | .3-.5 | 1 | 3.0 a |
| | .1-.2 | 8 | 0.6 a | .3-.5 | 1 | 0.0 a | .3-.5 | 1 | 0.0 a | .1-.2 | 4 | 0.0 b |
| Beds per unit area | .3-.5 | 1 | 3.3 a | .1-.2 | 8 | 0.0 a | .1-.2 | 8 | 3.0 a | .3-.5 | 1 | 10.0 a |
| | .1-.2 | 8 | 3.1 a | .3-.5 | 1 | 0.0 a | .3-.5 | 1 | 0.0 a | .1-.2 | 4 | 0.0 b |
| Percent plots foraged[1] | | | | .3-.5 | 1 | 3.1 a | .1-.2 | 8 | 8.5 a | .1-.2 | 4 | 0.0 a |
| | | | | .1-.2 | 8 | 1.3 a | .3-.5 | 1 | 0.0 a | .3-.5 | 1 | 0.0 a |

*Means with same letter not significantly different ($p>0.05$)

[1] Not measured in winter.

Table 8. White-tailed deer seasonal utilization of openings by size (ha) class, southwest region Shawnee National Forest.

| | SEASON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Spring | | | Summer | | | Fall | | |
| Index | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ | Size | N | $\bar{X}$ |
| Total trails | .6-.9 | 6 | 5.3 a* | .3-.5 | 22 | 4.4 a | ≥1.0 | 1 | 2.0 a | .6-.9 | 6 | 2.0 a |
| | .3-.5 | 23 | 3.8 a b | .6-.9 | 6 | 4.2 a | .6-.9 | 6 | 2.0 a | .3-.5 | 21 | 1.5 a |
| | .1-.2 | 16 | 2.6 a b | .1-.2 | 16 | 2.6 a | .3-.5 | 23 | 1.3 a | .1-.2 | 16 | 0.8 a |
| | ≥1.0 | 1 | 1.0 b | ≥1.0 | 1 | 2.0 a | .1-.2 | 16 | 0.8 a | ≥1.0 | 1 | 0.0 a |
| Trails per unit area | .1-.2 | 16 | 14.0 a | .1-.2 | 16 | 14.1 a | .1-.2 | 16 | 3.8 a | .1-.2 | 16 | 4.1 a |
| | .3-.5 | 23 | 10.0 a b | .3-.5 | 22 | 11.8 a | .3-.5 | 23 | 3.4 a | .3-.5 | 21 | 3.9 a |
| | .6-.9 | 6 | 7.7 a b | .6-.9 | 6 | 5.9 a | .6-.9 | 6 | 3.2 a | .6-.9 | 6 | 3.1 a |
| | ≥1.0 | 1 | 0.8 b | ≥1.0 | 1 | 1.7 a | ≥1.0 | 1 | 1.7 a | ≥1.0 | 1 | 0.0 a |
| Total beds | .6-.9 | 6 | 2.7 a | .1-.2 | 16 | 0.3 a | .1-.2 | 16 | 0.1 a | ≥1.0 | 1 | 1.0 a |
| | .3-.5 | 23 | 2.0 a | .3-.5 | 22 | 0.0 a | .3-.5 | 23 | 0.0 a | .6-.9 | 6 | 0.2 b |
| | .1-.2 | 16 | 1.3 a | .6-.9 | 6 | 0.0 a | .6-.9 | 6 | 0.0 a | .1-.2 | 16 | 0.1 b |
| | ≥1.0 | 1 | 0.0 a | ≥1.0 | 1 | 0.0 a | ≥1.0 | 1 | 0.0 a | .3-.5 | 21 | 0.1 b |
| Beds per unit area | .1-.2 | 16 | 6.9 a | .1-.2 | 16 | 1.3 a | .1-.2 | 16 | 0.3 a | ≥1.0 | 1 | 0.8 a |
| | .3-.5 | 23 | 5.2 a | .3-.5 | 22 | 0.0 a | .3-.5 | 23 | 0.1 a | .1-.3 | 16 | 0.6 a |
| | .6-.9 | 6 | 3.7 a | .6-.9 | 6 | 0.0 a | .6-.9 | 6 | 0.0 a | .6-.9 | 6 | 0.3 a |
| | ≥1.0 | 1 | 0.0 a | ≥1.0 | 1 | 0.0 a | ≥1.0 | 1 | 0.0 a | .3-.5 | 21 | 0.3 a |
| Percent plots foraged[1] | | | | .1-.2 | 16 | 3.4 a | ≥1.0 | 1 | 14.8 a | .6-.9 | 6 | 4.0 a |
| | | | | .6-.9 | 6 | 2.0 a | .1-.2 | 16 | 8.6 a | .3-.5 | 21 | 3.5 a |
| | | | | .3-.5 | 22 | 1.7 a | .3-.5 | 23 | 6.5 a | .1-.2 | 16 | 0.8 a |
| | | | | ≥1.0 | 1 | 0.0 a | .6-.9 | 6 | 5.5 a | ≥1.0 | 1 | 0.0 a |

*Means with same letter not significantly different ($p>0.05$).

[1] Not measured in winter.

small openings with heavy woody cover, which influenced available forage in all seasons. East and southwest regions exhibited slightly higher foraging in smaller openings during spring (Tables 4 and 8), while middle and Oakwood bottoms regions exhibited more foraging in larger openings (Tables 5 and 7). Summer brought complete reversals from spring trends in mean percent foraging as it related to opening size in east and southwest regions. Larger ($\geq$ 1.0 ha) openings were foraged more than smaller ones. Fall trends were similar to summer for all regions. However, more smaller openings in the middle region contained cereal grain food plots which produced higher mean foraging values for smaller openings.

Shape.--The relative amount of "edge" provided by a particular opening is a function of its size and shape. An index to opening shape was obtained by computing perimeter/area ratios and analyzing these according to size class of opening.

The relationship of opening shape to relative deer utilization was examined by determining if, within a given opening size and/or size class, a significant ($P<0.10$) positive correlation existed between perimeter/size ratio and total number of trails, beds and percent foraging over all seasons. One would expect elongated openings to intersect more deer trails and indeed the number of trails associated with openings in the east region was significantly correlated with perimeter/area ratio for 0.7 ha openings in winter ($r=0.82$, $N=13$), 0.3 ha openings in summer ($r=0.55$, $N=13$), and 0.4 ha openings in fall ($r=0.45$, $N=16$). Positive correlations between trails and perimeter were also recorded for 0.3 and 0.5 ha openings in the southwest region. However, the only significant correlation in the northwest region occurred in spring, where total trails

in 0.4 ha openings were negatively correlated (r=-0.66, N=11) with perimeter.

The relationship between total number of beds and perimeter in eastern openings was not as clear as for trails. Only summer utilization of 1.1 ha openings showed a significant correlation (r=0.80, N=6), and in the southwest only 0.4 ha openings in winter were correlated (r=0.81, N=6). Middle and Oakwood bottom regions showed no positive correlations and northwest openings revealed negative correlations between beds and perimeter in 0.2 and 0.3 ha openings in winter (r=-0.49, N=17) and 0.3 ha openings in fall (r=-0.62, N=13). In certain instances, elongation of small openings might actually lessen use by diminishing the attractiveness or potential opportunities for utilization (i.e. bedding, foraging). In contrast, large (1.1 ha) openings in the east showed a positive relationship between beds and perimeter/area ratio. This suggests that departure from oval or square shapes may be more important as opening size increases.

Distance from deer bedsites to nearest edge was examined, in relation to opening size and shape. Distances decreased with increasing edge within larger openings; but, within 0.1-0.2 ha openings, mean distance from beds to edge did not vary with perimeter. Regardless of opening size or shape class, most beds (68%) were located within 10.5 meters of an edge.

Opening shape may not influence foraging as much as vegetative composition of the opening. Percent foraging was negatively correlated with perimeter/area ratio in spring for 0.6 ha east region openings (r=-0.54) as well as 0.2 ha southwest openings (r=-0.52). Also a negative relationship between use and perimeter/area ratio existed in 0.3 ha east region openings (r=-0.45) in the fall. This contrasted with 0.4 ha openings from the southwest,

where increased perimeter was positively correlated (r=0.84) with increased foraging. Observations revealed that if preferred forage was abundant throughout an opening or woody cover was present, deer would utilize the entire opening regardless of size and/or shape.

Mean distance from forage plots to nearest edge decreased as perimeter increased, as expected; but within 0.1-0.2 ha openings, distances were less in non-elongated openings. This could indicate more uniform utilization of small openings. Differences in mean distances from forage plots to edge between elongated and non-elongated openings within the three larger size classes were not appreciable. Regardless of size class or perimeter/area ratio, most foraged plots (82%) were within 10 meters of an edge. This indicated that deer were probably staying close to the edge in larger openings; but observations revealed that if a preferred food source was available or woody cover was present, they would utilize the entire opening.

Density.--Density of maintained openings varied greatly by physiographic division, district, and compartment within the Forest. For this reason, we attempted to determine if a relationship existed between use of openings by deer and the number of other openings within a 1.0 km radius.

Total number of trails leading into a given opening was often correlated with the number of nearby openings, but the relationship varied by region. Openings in the east region surrounded by only 0-2 other openings contained higher numbers of trails than did those in more dense situations in winter, spring, and fall; those with 3-5 other openings had higher means in summer (Table 9, Appendix E1). Similar trends were observed in the middle region (Table 10, Appendix E2). In the northwest, openings surrounded by 0-2 others had higher means in summer and fall (Table 11, Appendix E3); but

Table 9. White-tailed deer seasonal utilization of openings as related to number of openings within a 1.0 km radius, east region Shawnee National Forest.

| Index | Winter<br>Number of Openings | Winter<br>N | Winter<br>$\bar{X}$ | Spring<br>Number of Openings | Spring<br>N | Spring<br>$\bar{X}$ | Summer<br>Number of Openings | Summer<br>N | Summer<br>$\bar{X}$ | Fall<br>Number of Openings | Fall<br>N | Fall<br>$\bar{X}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total trails | 0-2 | 10 | 3.0 a* | 0-2 | 10 | 3.3 a | 3-5 | 27 | 2.1 a | 0-2 | 10 | 2.8 a |
| | 3-5 | 40 | 2.3 a b | 3-5 | 40 | 2.5 a | 0-2 | 8 | 1.9 a | ≥12 | 5 | 2.4 a |
| | 6-8 | 23 | 2.1 a b | ≥12 | 5 | 2.2 a | 6-8 | 22 | 1.4 a | 3-5 | 39 | 2.2 a |
| | 9-11 | 25 | 2.0 a b | 9-11 | 25 | 2.1 a | 9-11 | 20 | 1.2 a | 6-8 | 23 | 2.0 a |
| | ≥12 | 5 | 1.0 b | 6-8 | 23 | 1.9 a | ≥12 | 2 | 1.0 a | 9-11 | 25 | 1.9 a |
| Total beds | 0-2 | 10 | 0.3 a | 0-2 | 10 | 0.5 a | 6-8 | 22 | 1.1 a | 9-11 | 25 | 1.4 a |
| | 6-8 | 23 | 0.0 a b | 6-8 | 23 | 0.4 a | 0-2 | 8 | 1.0 a | ≥12 | 5 | 1.2 a |
| | 3-5 | 40 | 0.0 b | 3-5 | 40 | 0.2 a | 3-5 | 27 | 0.8 a | 0-2 | 10 | 0.9 a |
| | 9-11 | 25 | 0.0 b | 9-11 | 25 | 0.0 a | 9-11 | 20 | 0.2 a | 6-8 | 23 | 0.9 a |
| | ≥12 | 5 | 0.0 b | ≥12 | 5 | 0.0 a | ≥12 | 2 | 0.0 a | 3-5 | 39 | 0.7 a |
| Percent[1] plots foraged | | | | 6-8 | 23 | 15.0 a | 3-5 | 27 | 18.2 a | 3-5 | 39 | 15.0 a |
| | | | | 9-11 | 25 | 14.4 a | 9-11 | 20 | 16.8 a | 9-11 | 25 | 13.0 a |
| | | | | 3-5 | 40 | 11.7 a | ≥12 | 2 | 14.3 a | ≥12 | 5 | 12.1 a |
| | | | | ≥12 | 5 | 10.0 a | 6-8 | 22 | 12.8 a | 6-8 | 23 | 8.6 a |
| | | | | 0-2 | 10 | 9.9 a | 0-2 | 8 | 10.2 a | 0-2 | 10 | 8.2 a |

*Means with same letter not significantly different ($p>0.5$).

[1] Not measured in winter.

Table 10. White-tailed deer seasonal utilization of openings as related to number of openings within a 1.0 km radius, middle region Shawnee National Forest.

| | SEASON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Spring | | | Summer | | | Fall | | |
| Index | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ |
| Total trails | 6-8 | 19 | 3.1 a* | 0-2 | 3 | 2.7 a | 0-2 | 3 | 3.3 a | 0-2 | 3 | 7.7 a |
| | 0-2 | 3 | 3.0 a | 6-8 | 19 | 2.2 a | 6-8 | 18 | 2.8 a b | 3-5 | 5 | 2.6 b |
| | 9-11 | 3 | 3.0 a | 9-11 | 3 | 1.7 a | 3-5 | 5 | 2.6 a b | 6-8 | 19 | 2.5 b |
| | 3-5 | 5 | 0.8 a | 3-5 | 5 | 1.0 a | 9-11 | 2 | 0.5 b | 9-11 | 3 | 2.0 b |
| Total beds | 6-8 | 19 | 0.1 a | 0-2 | 3 | 2.3 a | 0-2 | 3 | 2.0 a | 0-2 | 3 | 3.7 a |
| | 0-2 | 3 | 0.0 a | 6-8 | 19 | 0.2 b | 6-8 | 18 | 1.6 a | 6-8 | 19 | 0.8 b |
| | 3-5 | 5 | 0.0 a | 3-5 | 5 | 0.0 b | 3-5 | 5 | 0.6 a | 3-5 | 5 | 0.2 b |
| | 9-11 | 3 | 0.0 a | 9-11 | 3 | 0.0 b | 9-11 | 2 | 0.0 a | 9-11 | 3 | 0.0 b |
| Percent plots foraged[1] | | | | 3-5 | 5 | 17.8 a | 6-8 | 18 | 21.8 a | 6-8 | 19 | 35.3 a |
| | | | | 0-2 | 3 | 14.8 a | 0-2 | 3 | 17.2 a | 9-11 | 3 | 28.6 a |
| | | | | 6-8 | 19 | 12.6 a | 3-5 | 5 | 11.0 a | 3-5 | 5 | 21.3 a |
| | | | | 9-11 | 3 | 10.2 a | 9-11 | 2 | 9.1 a | 0-2 | 3 | 16.0 a |

*Means with same letter not significantly different ($p>0.05$).

[1] Not measured in winter.

Table 11. White-tailed deer seasonal utilization of openings as related to number of openings within a 1.0 km radius, northwest region Shawnee National Forest.

| | SEASON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Spring | | | Summer | | | Fall | | |
| Index | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ |
| Total trails | ≥12 | 18 | 6.1 a* | 9-11 | 2 | 8.5 a | 0-2 | 3 | 3.3 a | 0-2 | 3 | 3.7 a |
| | 0-2 | 2 | 5.0 a | 0-2 | 3 | 8.0 a | 6-8 | 17 | 2.5 a | ≥12 | 17 | 3.1 a |
| | 9-11 | 2 | 4.5 a | ≥12 | 18 | 7.4 a | ≥12 | 18 | 2.2 a | 6-8 | 17 | 2.0 a |
| | 6-8 | 17 | 3.5 a | 3-5 | 13 | 5.6 a | 3-5 | 13 | 1.8 a | 9-11 | 2 | 2.0 a |
| | 3-5 | 13 | 3.5 a | 6-8 | 17 | 5.3 a | 9-11 | 2 | 1.5 a | 3-5 | 13 | 1.7 a |
| Total beds | ≥12 | 18 | 5.4 a | 6-8 | 17 | 0.2 a | 0-2 | 3 | 1.7 a | 6-8 | 17 | 0.6 a |
| | 0-2 | 2 | 4.0 a | ≥12 | 18 | 0.2 a | 6-8 | 17 | 0.7 a b | ≥12 | 17 | 0.6 a |
| | 9-11 | 2 | 2.5 a | 3-5 | 13 | 0.2 a | 3-5 | 13 | 0.5 a b | 9-11 | 2 | 0.5 a |
| | 6-8 | 17 | 2.0 a | 0-2 | 3 | 0.0 a | ≥12 | 18 | 0.4 a b | 3-5 | 13 | 0.4 a |
| | 3-5 | 13 | 1.8 a | 9-11 | 2 | 0.0 a | 9-11 | 2 | 0.0 b | 0-2 | 3 | 0.0 a |
| Percent plots foraged[1] | | | | 0-2 | 3 | 7.0 a | 6-8 | 17 | 18.3 a | 6-8 | 17 | 19.7 a |
| | | | | ≥12 | 18 | 6.6 a | 3-5 | 13 | 7.2 a | 0-2 | 3 | 15.1 a |
| | | | | 6-8 | 17 | 5.3 a | 0-2 | 3 | 7.0 a | 3-5 | 13 | 12.2 a |
| | | | | 3-5 | 13 | 3.2 a | ≥12 | 18 | 6.1 a | 9-11 | 2 | 1.2 a |
| | | | | 9-11 | 2 | 0.0 a | 9-11 | 2 | 3.0 a | ≥12 | 17 | 1.2 a |

*Means with same letter not significantly different ($p>0.05$).

[1] Not measured in winter.

those with 9-11 and $\geq$ 12 nearby openings had higher means in spring and winter. In contrast, relatively isolated Oakwood bottom openings (0-2 others within a 1.0 km radius) contained higher numbers of trails throughout all seasons (Table 12, Appendix E4). This variation may reflect a situation in which relatively isolated openings in a forested area receive more intensive use because they provide the only available open habitat for foraging and bedding, whereas clusters of openings receive heavy use because they are influencing local distribution of deer in that area.

Openings in the southwest region were surrounded by more extensive forest than other regions. This may explain why those associated with 12 or more other openings had higher mean number of trails leading into them in winter, spring, and summer (Table 13, Appendix E5). Increased diversity provided by large numbers of openings may offset, to some extent, lack of pasture/hayfield, and cropland. Within this region, mean distance between managed openings for those surrounded by 0-2 others was 675 m (range 48-2244) compared to only 79 m (range 10-284) for those surrounded by 12 or more. Availability of suitable opening sites is often limited; thus, existing groups of 9 or more were generally very close together and associated with stream bottoms or large ridge tops.

Effect of opening density on bedding varied by region and season. During winter and spring, east region openings surrounded by few (0-2) others showed highest mean numbers of beds (Table 9). During these periods, low opening densities may increase utilization of existing ones because of a lack of other suitable bedding sites and/or herbaceous forage sources. In summer, however, increased forage and concealment cover was associated with areas of higher opening densities; also, does and fawns were often

Table 12. White-tailed deer seasonal utilization of openings as related to number of openings within a 1.0 km radius, Oakwood bottoms region Shawnee National Forest.

| | SEASON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Spring | | | Summer | | | Fall | | |
| Index | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ |
| Total trails | 0-2 | 5 | 3.8 a* | 0-2 | 5 | 2.8 a | 0-2 | 5 | 0.6 a | 0-2 | 3 | 1.3 |
| | 3-5 | 4 | 1.0 a | 3-5 | 4 | 1.5 a | 3-5 | 4 | 0.0 a | 3-5 | 2 | 0.0 |
| Total beds | 0-2 | 5 | 1.2 a | 0-2 | 5 | 0.0 a | 3-5 | 4 | 0.5 a | 0-2 | 3 | 1.0 a |
| | 3-5 | 4 | 0.0 a | 3-5 | 4 | 0.0 a | 0-2 | 5 | 0.2 a | 3-5 | 2 | 0.0 a |
| Percent plots foraged[1] | | | | 0-2 | 5 | 2.6 a | 0-2 | 5 | 8.2 a | 0-2 | 3 | 0.0 a |
| | | | | 3-5 | 4 | 0.0 a | 3-5 | 4 | 6.6 a | 3-5 | 2 | 0.0 a |

*Means with same letter not significantly different ($p>0.05$)

[1] Not measured in winter.

Table 13. White-tailed deer seasonal utilization of openings as related to number of openings within a 1.0 km radius, southwest region Shawnee National Forest.

| | SEASON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Spring | | | Summer | | | Fall | | |
| Index | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ | Number of Openings | N | $\bar{X}$ |
| Total trails | ≥12 | 8 | 4.8 a* | ≥12 | 8 | 6.3 a | ≥12 | 8 | 2.1 a | 6-8 | 18 | 1.8 a |
| | 6-8 | 18 | 3.8 a | 6-8 | 18 | 3.9 a b | 6-8 | 18 | 1.2 a | ≥12 | 8 | 1.3 a |
| | 9-11 | 5 | 3.8 a | 0-2 | 5 | 3.2 b | 0-2 | 6 | 1.0 a | 9-11 | 4 | 1.0 a |
| | 0-2 | 6 | 2.5 a | 3-5 | 9 | 2.1 b | 3-5 | 9 | 0.9 a | 0-2 | 6 | 0.8 a |
| | 3-5 | 9 | 2.3 a | 9-11 | 5 | 1.8 b | 9-11 | 5 | 0.8 a | 3-5 | 8 | 0.4 a |
| Total beds | 9-11 | 5 | 3.4 a | 0-2 | 5 | 0.6 a | ≥12 | 8 | 0.3 a | 0-2 | 6 | 0.3 a |
| | ≥12 | 8 | 2.1 a b | 6-8 | 18 | 0.1 b | 0.2 | 6 | 0.0 b | 6-8 | 18 | 0.2 a |
| | 3-5 | 9 | 1.8 a b | 3-5 | 9 | 0.0 b | 6-8 | 18 | 0.0 b | 3-5 | 8 | 0.1 a |
| | 0-2 | 6 | 1.5 a b | 9-11 | 5 | 0.0 b | 9-11 | 5 | 0.0 b | 0-11 | 4 | 0.0 a |
| | 6-8 | 18 | 1.4 b | ≥12 | 8 | 0.0 b | 3-5 | 9 | 0.0 b | ≥12 | 8 | 0.0 a |
| Percent plots foraged[1] | | | | 0-2 | 5 | 8.7 a | 0-2 | 6 | 13.2 a | ≥12 | 8 | 4.5 a |
| | | | | 9-11 | 5 | 3.8 b | ≥12 | 8 | 10.6 a b | 6-8 | 18 | 3.2 a |
| | | | | 3-5 | 9 | 1.8 b | 9-11 | 5 | 9.5 a b | 9-11 | 4 | 2.0 a |
| | | | | 6-8 | 18 | 1.1 b | 6-8 | 18 | 5.5 a b | 3-5 | 8 | 1.1 a |
| | | | | ≥12 | 8 | 0.8 b | 3-5 | 9 | 2.8 b | 0-2 | 6 | 0.0 a |

*Means with same letter not significantly different ($p>0.05$).

[1] Not measured in winter.

seen near or flushed from openings during summer. East region openings were usually mowed in late summer or early fall and resulting new growth might have attracted deer when most forest vegetation was dead or dying. Thus, high numbers of mowed openings might have increased overall use by attracting deer.

In the middle region, openings surrounded by few (0-2) others had more beds in spring, summer and fall (Table 10); however, one very large opening within this group contained many beds because of its sheer size, and because it contained a warm-season grass and food plot component. Correcting for this, it appeared openings surrounded by 6-8 others were most heavily utilized by bedding deer throughout all seasons.

In the northwest, spring utilization of openings surrounded by 6-8 others was highest (Table 11); but many of the sampled openings had been disced and seeded to legumes the previous fall. Many openings were mowed before fall sampling, including all those disced the previous fall; thus, desirable forage conditions may have increased bedding in these openings which happened to occur in larger clusters. A possibly more accurate indication of the relationship between opening density and utilization in this region was obtained from summer data. During that season, relatively isolated openings had higher mean number of beds than other density groups.

Within the southwest region, mean number of beds was highest in openings surrounded by > 9 openings in winter and > 12 in summer (Table 13). This may indicate large numbers of openings influenced local deer distribution by attracting does with fawns in summer and providing more forage in winter. In fall, most beds were located in unmowed openings; within a given area, a lack of preferred bedding sites could increase use in isolated openings.

Effect of opening density upon foraging was not readily interpretable. Intuitively one would expect relatively heavy utilization of isolated openings in extensively forested areas. The best example of this condition would be in southwest region during spring. Those openings surrounded by few (0-2) others were foraged significantly more than openings with higher surrounding densities. Beyond this example, foraging was most likely dependent upon availability of preferred foods; and the variable findings were the result of distribution of preferred vegetation types and/or structure.

East Region

Winter.--Two variables, opening size and distance to water were most important in predicting the number of trails associated with individual openings ($R^2$=0.197, $P<0.10$). As size increased, so did the number of trails. Distance to water, though statistically important showed no discernable trends.

The total number of beds within openings was best accounted for by distance to closest managed opening and by opening size ($R^2$=0.144, $P<0.10$). Mean number of beds increased with distance between managed openings and with size of openings.

Spring.--Opening vegetation type, percent cropland within 1.0 km, and percent coniferous forest within 1.0 km were most important in predicting the number of trails leading into openings ($R^2$=0.242, $P<0.10$). Openings containing domesticated legumes, cool-season grasses and early secondary succession perennial forbs had more trails as did openings containing over 10% cropland within 1.0 km. Also, those with less than 30% pine within 1.0 km had more trails than those with more than 30% surrounding pine.

Number of beds within openings was best accounted for by distance to closest crop field and percent pasture within 1.0 km when variables were considered in combination ($R^2$=0.091, P<0.10). No discernable trend in beds and cropland distance was found, though openings over 1.0 km from cropland tended to have slightly more beds. Number of beds was positively related to nearby pasture/hayfield acreage.

Foraging in openings was associated only with distance to cropland when all possible variables were considered ($R^2$=0.150, P<0.10), with percent foraging declining as distance to cropland decreased. In this region, openings close to agriculture fields may be less important in providing forage.

Summer.--Distance to cropland and opening size were most important in predicting number of trails leading into openings ($R^2$=0.224, P<0.10). Openings within 400 m of cropland had more trails associated with them; and, as opening size increased so did number of trails.

Number of beds within openings was best accounted for by distance to water, percent pasture/hayfield within 1.0 km, opening vegetation type, and percent cropland within a 1.0 km radius when all variables were considered ($R^2$=0.385, P<0.10). Beds were more numerous in openings closest to permanent water. Openings surrounded by over 10% pasture or hayfield within 1.0 km also contained more beds, as did those comprised of grasses and/or planted legumes.

Opening vegetation type and distance to cropland accounted for the most variance associated with foraging when all variables were considered ($R^2$=0.501, P<0.10). Openings containing planted legumes were foraged more than other vegetation types. In contrast to spring, however, foraging increased as distance to cropland decreased.

_Fall_.--The combination of opening size, percent cropland within 1.0 km, and opening vegetation type best predicted number of trails associated with individual openings ($R^2=0.401$, $P<0.10$). Openings surrounded by over 10% cropland had more trails associated with them, as did larger openings and those containing early secondary succession perennial forbs and/or planted legumes.

Number of beds within openings was associated only with opening size (positively) when all variables were considered simultaneously ($R^2=0.117$, $P<0.10$). However, when considered individually, opening size, mowed versus unmowed, percent woody vegetation greater than 2 m, and percent deciduous habitat within 1.0 km were important. Openings not mowed before fall sampling had more beds, as did those with more woody vegetation and those surrounded by approximately 50-75% deciduous forest.

Foraging within openings was best accounted for by opening vegetation type, number of openings within 1.0 km, distance to nearest cropfield, opening size, and distance to permanent water ($R^2=0.644$, $P<0.10$). Those openings containing cereal grains were utilized more than all others; those containing planted legumes ranked second. Number of openings within 1.0 km, distance to crop, and size were statistically important, but no discernable trends were evident. As distance to permanent water decreased, mean percent foraging increased.

### Middle Region

_Winter_.--When all variables were considered, only percent cropland was important in accounting for variation associated with trails and individual openings ($R^2=0.341$, $P<0.10$). Those surrounded by over 4% cropland within 1.0 km contained more trails. No variables were significantly important when considered individually.

Number of beds within openings was positively related to distance to closest non-forested habitat ($R^2=0.113$, $P<0.10$). When variables were considered individually, distance to non-forested habitat, distance to water, number of surrounding openings, distance to nearest managed opening, and percent cropland within 1.0 km were considered important. However, only distance to non-forested habitat and percent cropland revealed discernable trends. As percent cropland increased, number of beds decreased.

Spring.--Percent cropland and deciduous habitat best accounted for variation associated with number of trails leading into openings ($R^2=0.322$, $P<0.10$). Openings with over 4% cropland within 1.0 km contained more trails, as did those surrounded by over 75% deciduous habitat. When variables were considered individually, percent cropland and deciduous habitat within 1.0 km, distance to managed opening, percent open habitat within 1.0 km, and distance to nearest pasture or hayfield were important. As distance to managed opening increased, number of trails decreased. Overall, those openings within 400 m of each other and which comprised the available open herbaceous habitat in an area received more use.

No variables, either individually or in combination were found to be significant in accounting for variation associated with number of beds.

Foraging within openings was related to percent cropland and other open habitat within 1.0 km, and distance to water when variables were examined collectively ($R^2=0.659$, $P<0.10$). Foraging increased as percent cropland and open habitat increased, but declined as distance to permanent water increased. When considered individually, only percent open habitat and cropland were important.

Summer.--Percent pasture/hayfield and deciduous habitat within 1.0 km and opening size best accounted for variation associated with trails, when all variables were considered ($R^2=0.555$, $p<0.10$). Number of trails decreased with increasing representation of nearby pasture/hayfield acreage. Those openings surrounded by over 75% and under 50% deciduous habitat contained more trails. Opening size was positively related to number of trails.

No variables were found to account for variation exhibited in number of beds associated with openings.

Variation in foraging was best explained by opening vegetation type, distance to closest managed opening, percent coniferous habitat within 1.0 km, distance to water and pasture/hayfield, and surrounding percent open habitat within 1.0 km, when variables were considered individually; but no variables were important when considered simultaneously. Openings with early secondary succession vegetation were used more extensively. As distance to pasture increased, foraging decreased, and those surrounded by 0-4% open habitat were foraged more as were openings surrounded by over 9% coniferous habitat and those which were within 400 m of water.

Fall.--Opening size, distance to closest managed opening, distance to pasture/hayfield and distance to cropland were important variables when considered individually though none were significant in combination. Larger openings had more trails as did those farther from other openings but associated with nearby open habitat and cropland.

Distance to managed opening, distance to water, opening vegetation type, and percent open and cropland within a 1.0 km radius were important in predicting number of beds associated with openings, when all variables

were considered in ($R^2$=0.810, P<0.10). Openings farthest (over 400 m) from other managed openings had significantly more beds. Distance to water, though statistically significant, revealed no discernable trends. Cool-season grass openings had more beds, as did those associated with nearby open habitat. Openings surrounded by 4-10% cropland also contained more beds.

No variables predicted foraging either singly or in combination; but observations suggested those openings containing cereal grains were utilized more. Mean foraging values associated with this type were over twice as high as the second most used type.

### Northwest region

Winter.--In the presence of other variables, only deciduous habitat within a 1.0 km radius accounted for significant variation in number of trails ($R^2$=0.168, p<0.10). Openings surrounded by approximately 50-75% deciduous habitat had more trails than those with over 75%. Percent pasture/hayfield and opening size as well as deciduous habitat were important individually, with larger openings and those surrounded by over 10% pasture/hayfield habitat having more trails.

Opening size, percent of opening covered by woody vegetation less than 2 m, and percent cropland within 1.0 km best accounted for variation associated with beds ($R^2$=0.425, p<0.10); all 3 showed a positive relationship.

Spring.--Distance to water and cropland, percent woody growth less than 2 m, and opening size best accounted for variation associated with trails when variables were considered in combination ($R^2$=0.436, p<0.10). Openings within 400 m of water contained more trails, as did those within 400-1000 m of cropland. Larger openings and those comprised of 10-30% woody growth less than 2 m also had more trails.

Total number of beds was best predicted by opening size ($R^2=0.230$, $p<0.10$), which showed a positive relationship with the index. When variables were considered individually, size, number of surrounding openings, percent woody growth less than 2 m, and percent cropland, pasture/hayfield, deciduous, and coniferous habitats within 1.0 km, as well as opening vegetation type were important. Those openings dominated by warm-season grasses had significantly more beds than all other types; bedding also increased with increased woody growth. Openings surrounded by over 10% cropland maintained more beds, as did those with approximately 50-75% deciduous habitat. Increased percent coniferous habitat was related to an increase in mean number of beds; even though number of surrounding openings was considered statistically significant, no discernable trend was evident.

When variables were considered in combination, percent deciduous forest within 1.0 km, distance to pasture or hayfield, percent woody growth over 2 m, and percent coniferous habitat within 1.0 km were important in predicting foraging in openings ($R^2=0.362$, $p<0.10$). Openings with 50-75% deciduous forest within a 1.0 km radius were foraged more than those with over 75%. Openings over 1.0 km from a pasture or hayfield showed more foraging, as did those with over 25% woody growth greater than 2 m. As surrounding percent of coniferous forest increased, foraging decreased.

Summer.--Percent nearby deciduous and cropland habitat along with woody growth less than 2 m within openings accounted for variance associated with trails ($R^2=0.454$, $p<0.10$). Openings surrounded by 50-75% deciduous forest and relatively little cropland had more trails. No discernable relation was evident between woody vegetation and trails.

Number of beds was negatively related to percent pasture/hayfield within a 1.0 km radius when variables were considered individually. No variables were significant when considered in combination.

Variation in percent foraging was best accounted for by opening vegetation type and percent coniferous habitat within 1.0 km ($R^2$=0.547, $p<0.10$). Planted clover openings and those surrounded by less than 8% coniferous habitat were foraged more than other types.

Fall.--Percent cropland within 1.0 km and number of surrounding openings were most important in predicting number of trails leading into openings ($R^2$=0.277, $p<0.10$). Openings surrounded by 4-10% cropland had higher mean number of trails, but no discernable trends were associated with number of surrounding openings.

Number of beds within openings was positively related to percent cropland within a 1.0 km radius ($R^2$=0.187, $p<0.10$).

Opening vegetation type, surrounding percent pasture/hayfield habitat, and number of surrounding openings within 1.0 km accounted for the most variance associated with foraging when variables were considered simultaneously ($R^2$=0.692, $p<0.10$). Planted clover openings were foraged more than other types, but as percent pasture/hayfield habitat increased within 1.0 km, foraging decreased.

Southwest

Winter.--Distance to nearest pasture/hayfield and opening size best accounted for variation associated with number of trails when variables were considered simultaneously ($R^2$=0.299, $P<0.10$). Those openings further than 1.0 km from a pasture or hayfield had significantly more trails associated with them, as did larger openings.

No variables were significantly related to number of beds.

Spring.--Only distance to pasture/hayfield was important in predicting number of trails associated with individual openings ($R^2$=0.124, P<0.10). As in winter, those farther than 1.0 km had more trails.

Again, no variables were found related to number of beds.

Variable foraging was best explained by distance to nearest managed opening, and number of surrounding openings ($R^2$=0.712, P<0.10). As distance to other openings increased, percent foraging decreased; but those within 400 m of each other were not utilized very differently. No overall trends were discernable in relation to density; however, openings surrounded by 0-2 others were foraged significantly more.

Summer.--Presence of woody growth over 2 m, surrounding open habitat, and opening size were important in predicting number of trails ($R^2$=0.485, P<0.10). Larger openings had more trails as did openings with less than 25% woody growth over 2 m and those surrounded by 5-10% other open habitat.

Variation associated with number of beds was best explained by percent open habitat within a 1.0 km radius, and distance to water ($R^2$=0.342, P<0.10). Openings surrounded by over 10% open habitat had more beds, as did openings over 400 m from water.

Foraging in openings was associated with number of surrounding openings, percent of opening comprised of woody growth less than 2 m, and opening size ($R^2$=0.427, p<0.10). No discernable trends were evident between foraging and number of openings; those surrounded by 0-2 others were foraged more, with those surrounded by 12 or more just slightly less. Similarly, no obvious trends were associated with percent woody growth nor with opening size.

Fall.--No variables were related to number of trails when considered in combination; however, distance to pasture or hayfield was important individually. Those farthest from pasture/hayfield had slightly more trails associated with them.

Similarly, no combination of variables was related to number of beds, but percent woody growth over 2 m, percent coniferous habitat within 1.0 km, size, opening vegetation type, number of surrounding openings, and distance to managed opening were important individually. As percent woody growth over 2 m increased, number of beds decreased; but those with a sassafras, sumac, persimmon vegetation type had more beds. Larger openings contained more beds, as did those surrounded by 0-2 openings. As distance to managed opening increased, mean number of beds decreased, and the same relationship existed with distance to non-forested habitat. When surrounding percent of coniferous habitat increased, mean number of beds increased.

Whether an opening had been mowed, percent woody growth less than 2 m, and vegetation type were associated with foraging when variables were considered in combination ($R^2=0.672$, $P<0.10$). Those mowed recently had been foraged more; and, related to this, those which contained over 10% woody growth were foraged more because of abundant new growth. Openings containing a planted legume component showed the highest incidence of foraging.

## Seasonal and Regional Summary

Winter use of openings by white-tailed deer was substantial. In general, openings in the east, middle and northwest regions, where many active farms are adjacent to Forest Service property, contained more trails

when surrounded by 50-75% deciduous forest. Increased utilization was also evident in openings surrounded by 10% cropland and/or 10% pasture/hayfield. Use of openings for bedding increased as distance to nearest managed opening or other non-forested habitat increased.

In larger deciduous stands, the number of trails intersecting openings increased as distance to private pasture and/or hayfield increased. As expected, openings that provided the only open habitat within an area were utilized more.

Seasonal use of openings was greatest in spring. Openings in predominantly forested areas (50-75% deciduous forest) tended to be utilized heavily for foraging, possibly indicating the contribution of openings in such areas to food supplies. However, as surrounding coniferous habitat increased, number of trails decreased. More trails were found leading into openings surrounded by ≥ 10% cropland; but foraging tended to be less in openings with nearby cropland. Other factors which also appeared to promote use where proximity to water, representation of planted legumes or cool-season grasses and presence of at least 25% woody vegetation.

In larger timbered areas of the southwest region, increased foraging was associated with isolated openings as well as those in clusters. Evidently isolated openings were utilized because of a lack of comparable habitat whereas those in clusters attracted more deer.

Openings containing a legume component were extensively utilized in summer regardless of forest setting. Those in close proximity to cropland but surrounded by < 10% intersected more trails and were foraged more. In the southwest region, isolated openings as well as those in clusters (≥ 12) were utilized more.

Openings in compartments within close proximity to private crop fields were utilized most in fall. However, if an opening contained cereal grains or planted legumes, foraging was substantial regardless of setting.

In the southwest region, openings containing legumes were foraged heavily; mowing of woody vegetation produced desirable forage which was also readily utilized. Unmowed openings dominated by sassafras, sumac, and persimmon appeared favored for bedding.

Analyses of utilization indices by season and region revealed that opening vegetation structure as well as composition influenced use. Deer bedded in grassy portions of openings most often; many bedsites were associated with warm-season grasses and/or were adjacent to or under sumac, sassafras and other woody species. During 1986 sampling, 42 of 52 bedsites at which vegetation data were recorded, were within 1 m of woody growth. A woody growth component was more prevalent in Murphysboro and Jonesboro districts openings which were mowed on a 3 and 4 year rotation respectively. Openings located in the Vienna District were usually mowed every year; thus, woody growth was less prevalent than in Murphysboro and Jonesboro openings.

Besides providing concealment, new growth associated with woody vegetation was heavily utilized during all seasons. In spring, new growth of rose and blackberry were foraged extensively; while in summer, blackberry and trumpet creeper were important, especially the latter since new growth was available later in the season. In fall, mature woody plants were utilized much less extensively. In contrast, openings that had been previously mowed and provided new growth of herbaceous and woody species (e.g. blackberry) were heavily utilized.

[illegible]

[illegible]

[illegible]

[illegible]

There was seasonal variation in use of openings by feeding deer. In spring, approximately 25% of openings sampled showed no evidence of foraging; however, over 10% of the plots examined had been foraged in 40% of the openings. Winter wheat and/or clover were the most frequently foraged species in 9 of the 13 openings in which at least 25% of the sample plots had been foraged.

In summer, approximately 12% of openings sampled contained no foraged plots; but over 10% of the plots had been foraged in 50% of the openings visited. Red, white and ladino clovers, Queen Ann's lace, tick trefoil, and grasses were the most fequently foraged herbaceous species. Red/white clover was the most commonly used forage in 16 of the 23 openings in which at least 25% of the sample plots showed sign of deer use. Also, hairy aster, field goldenrod, daisy fleabane, and brown-eyed susan were observed to be utilized heavily when abundant. Observations revealed when less than 10% of an opening was comprised of domestic legumes, use was generally minimal; however, utilization increased as representation of such vegetation exceeded 25%.

In fall, 26% of the openings visited showed no evidence of foraging. Over 10% of the plots had been foraged in 25% of the openings sampled. Percent foraging was twice as high in openings containing cereal grain food plots. Fourteen of the 30 openings in which at least 25% of the sample plots showed sign of deer foraging contained cereal grains. Cow pea and buckwheat were heavily foraged in these situations, but there was little or no use of milo and millet. In the absence of cereal grains, domestic legumes were utilized 2 to 3 times as much as other types; 7 of the 30 most heavily foraged openings were of this type. Disturbance

associated with previous food plot establishment produced conditions favorable for reseeding native and domestic legumes, and forbs. Within these openings, sweet clover and wild carrot were foraged when available.

Late summer mowing caused most plants to resprout before fall sampling. When this occurred, a wide variety of species was utilized; but new growth associated with woody plants was apparently favored. A complete list of species foraged is attached (Appendix F).

## Breeding Songbirds

Forest openings influenced the relative abundance and species composition of woodland breeding birds with the degree of influence varying with opening size and vegetational characteristics as well as surrounding timber type. Total and mean number of species and individuals as well as bird diversity were positively correlated with opening size and increased representation of woody cover within the opening.

### Oak-hickory Stands

Indigo buntings, American goldfinches, common yellowthroats, white-eyed vireos, and yellow-breasted chats were dominant in openings, accounting for 78% of the individuals (Table 14). Indigo buntings and blue-gray gnatcatchers were most numerous along edges, accounting for 27% of the individuals (Table 14). Even though more species were found along edges, equitability was lower as a result of being dominated by a few species. Acadian flycatchers, blue jays, cardinals, Carolina chickadees, eastern wood pewees, Kentucky warblers, tufted titmice, and yellow-billed cuckoos were common throughout all forest segments. Five of the 0.3-0.6 ha openings were located in upland riparian habitat; a small stream was within 20 m, thus several bird species dependent on such habitat were present. But,

Table 14. Avian species detected in each of five transect segments during three censuses of 21 openings located in mature deciduous forest in the Shawnee National Forest, Spring 1985 and 1986.

| Species | Within Opening | Distance from opening (m) 0-25 | 25-50 | 50-75 | 75-100 | Total |
|---|---|---|---|---|---|---|
| Acadian flycatcher<br>*Empidonax virescens* | 1 | 14 | 16 | 15 | 19 | 65 |
| American crow<br>*Corvus brachyrhynchos* | | | 1 | | | 1 |
| American goldfinch<br>*Carduelis tristis* | 25 | 7 | | 1 | 2 | 35 |
| American redstart<br>*Setophaga ruticilla* | 1 | 2 | | | | 3 |
| Barred owl<br>*Strix varia* | | | 1 | | | 1 |
| Black-billed cuckoo<br>*Coccyzus erythropthalmus* | | | | 1 | | 1 |
| Blue-gray gnatcatcher<br>*Polioptila caerulea* | 3 | 26 | 3 | 5 | 7 | 44 |
| Blue jay<br>*Cyanocitta cristata* | 1 | 8 | 14 | 7 | 10 | 40 |
| Brown-headed cowbird<br>*Molothrus ater* | 2 | 9 | 9 | 2 | 2 | 24 |
| Brown thrasher<br>*Toxostoma rufum* | | 1 | | | | 1 |
| Cardinal<br>*Cardinalis cardinalis* | 1 | 13 | 7 | 8 | 5 | 34 |
| Carolina chickadee<br>*Parus carolinensis* | 3 | 15 | 6 | 5 | 5 | 34 |
| Carolina wren<br>*Thryothorus ludovicianus* | | 2 | 2 | 4 | 3 | 11 |
| Cerulean warbler<br>*Dendroica cerulea* | | | 1 | | 1 | 2 |
| Chimney swift<br>*Chaetura pelagica* | 4 | 1 | 1 | | 2 | 8 |

Table 14. Continued.

| Species | Within Opening | Distance from opening (m) | | | | |
|---|---|---|---|---|---|---|
| | | 0-25 | 25-50 | 50-75 | 75-100 | Total |
| Common flicker<br>*Colaptes auratus* | | | 2 | 1 | | 3 |
| Common grackle<br>*Quiscalus quiscula* | 1 | | | | | 1 |
| Common yellowthroat<br>*Geothlypis trichas* | 20 | 10 | | | | 30 |
| Downy woodpecker<br>*Picoides pubescens* | 1 | 7 | 5 | 3 | 3 | 19 |
| Eastern phoebe<br>*Sayornis phoebe* | 1 | | | 1 | | 2 |
| Eastern wood peewee<br>*Contopus virens* | 1 | 4 | 13 | 17 | 9 | 44 |
| Field sparrow<br>*Spizella pusilla* | 1 | | | | | 1 |
| Great-crested flycatcher<br>*Myiarchus crinitus* | 1 | 5 | 4 | 3 | 5 | 18 |
| Green-backed heron<br>*Butorides virescens* | 1 | | | | | 1 |
| Hairy woodpecker<br>*Picoides villosus* | | 1 | | 1 | | 2 |
| Indigo bunting<br>*Passerina cyanea* | 68 | 82 | 13 | 10 | 9 | 182 |
| Kentucky warbler<br>*Oporornis formosus* | 1 | 6 | 6 | 9 | 8 | 30 |
| Louisiana waterthrush<br>*Seiurus motacilla* | | 2 | 1 | 1 | 3 | 7 |
| Mourning dove<br>*Zenaida macroura* | | | 1 | 2 | 5 | 8 |
| Northern oriole<br>*Icterus galbula* | | | | 1 | | 1 |

Table 14. Continued.

| Species | Within Opening | Distance from opening (m) 0-25 | 25-50 | 50-75 | 75-100 | Total |
|---|---|---|---|---|---|---|
| Orchard oriole<br>*Icterus spurius* | 1 | | | | | 1 |
| Ovenbird<br>*Seiurus aurocapillus* | | 1 | | 1 | | 2 |
| Parula warbler<br>*Parula americana* | | 5 | 2 | 6 | 2 | 15 |
| Pileated woodpecker<br>*Dryocopus pileatus* | | 2 | 2 | 4 | 2 | 10 |
| Red-bellied woodpecker<br>*Melanerpes carolinus* | | 4 | 6 | 2 | 3 | 15 |
| Red-eyed vireo<br>*Vireo olivaceus* | | 2 | 2 | 3 | 3 | 10 |
| Red-winged blackbird<br>*Agelaius phoeniceus* | 3 | 1 | | | | 4 |
| Ruby-throated hummingbird<br>*Archilochus colubris* | 5 | | | | 1 | 6 |
| Rufous-sided towhee<br>*Pipilo erythrophthalmus* | 3 | 9 | 2 | 2 | 2 | 18 |
| Scarlet tanager<br>*Piranga olivacea* | | 1 | 9 | 3 | 2 | 15 |
| Summer tanager<br>*Piranga rubra* | 1 | 4 | 9 | 6 | 9 | 29 |
| Tufted titmouse<br>*Parus bicolor* | | 12 | 10 | 15 | 4 | 41 |
| White-breasted nuthatch<br>*Sitta carolinensis* | | 7 | 10 | 5 | 4 | 26 |
| White-eyed vireo<br>*Vireo griseus* | 13 | 14 | 2 | 2 | 5 | 36 |
| Wild turkey<br>*Meleagris gallopavo* | 1 | | | | | 1 |

Table 14. Continued.

| Species | Within Opening | Distance from opening (m) 0-25 | 25-50 | 50-75 | 75-100 | Total |
|---|---|---|---|---|---|---|
| Wood thrush<br>*Hylocichla mustelina* | | 4 | 8 | 1 | 5 | 18 |
| Worm-eating warbler<br>*Helmitheros vermivorus* | | 1 | 8 | 10 | 7 | 26 |
| Yellow-billed cuckoo<br>*Coccyzus americanus* | | 9 | 7 | 7 | 8 | 31 |
| Yellow-breasted chat<br>*Icteria virens* | 13 | 4 | | | | 17 |
| Yellow-throated vireo<br>*Vireo flavifrons* | 1 | 2 | | 1 | 1 | 5 |
| Total | 178 | 397 | 183 | 175 | 156 | 989 |
| Species richness (S) | 28 | 36 | 32 | 35 | 32 | 50 |
| Species diversity (H') | 2.248 | 2.911 | 3.173 | 3.191 | 3.227 | |

these did not alter the overall results even when only openings considered were upland dry or upland riparian. However, when upland and riparian openings were separated within this size class, a positive relationship existed between species richness within the edge and opening size.

Within oak-hickory stands, 0.1-0.2 ha openings were apparently too small to concentrate either numbers or species along their edges (Table 15, Appendix G1). Even though mean number of individuals along the edge was similar for 0.1-0.2 and 0.3-0.6 ha openings, almost the entire edge was sampled in the former. Also, species richness was lower within the edge of 0.1-0.2 ha openings when compared to the interior forest; this contrasted with larger openings, which had more species along their edges as compared to interior forest segments. Diversity of breeding songbirds was greater at the forest-opening transition than within openings for all size classes of openings; however, diversity at the edge was lower than that associated with deeper forest segments.

### Southern Pine Stands

The effect of opening size on the distribution of birds within southern pine stands was not as evident as in deciduous habitat. Structural differences/similarities between surrounding managed and unmanaged stands were apparently more important in influencing abundance, distribution, and composition. Because of small sample sizes and the influence of wolf trees in the smallest openings, the relationship of opening size and distribution of associated birds could not be adequately assessed; but, in 3 of the 5 pine groups examined, the edge segment contained more species (Table 16, Appendix H). Within openings, common yellowthroats, field sparrows, indigo buntings and American goldfinches accounted for 55% of the individuals (Table 17).

Table 15. Variation in breeding bird abundance and species richness and diversity indices for various size (ha) openings, within mature deciduous habitat of the Shawnee National Forest.

| Variable | N | Within Opening | Distance from opening (m) | | | |
|---|---|---|---|---|---|---|
| | | | 0-25 | 25-50 | 50-75 | 75-100 |
| | | 0.1-0.2 ha openings | | | | |
| | 4 | | | | | |
| $\bar{x}$ Species | | 0.4 | 2.7 | 2.3 | 2.2 | 2.6 |
| x Individuals | | 0.6 | 4.0 | 2.3 | 2.4 | 2.7 |
| H'$^1$ | | 1.242 | 1.733 | 3.039 | 2.755 | 2.713 |
| S$^2$ | | 4 | 11 | 22 | 18 | 17 |
| | | 0.3-0.6 ha openings | | | | |
| | 11 | | | | | |
| $\bar{x}$ Species | | 2.0 | 4.0 | 2.7 | 2.6 | 2.1 |
| x Individuals | | 2.5 | 4.7 | 3.0 | 2.9 | 2.3 |
| H' | | 2.287 | 3.031 | 3.084 | 3.096 | 3.190 |
| S | | 21 | 31 | 29 | 30 | 29 |
| | | 0.7-1.0 ha openings | | | | |
| | 6 | | | | | |
| $\bar{x}$ Species | | 3.3 | 4.0 | 2.6 | 2.4 | 2.7 |
| $\bar{x}$ Individuals | | 5.0 | 5.5 | 2.8 | 2.6 | 3.0 |
| H' | | 1.981 | 2.691 | 2.851 | 2.998 | 2.817 |
| S | | 16 | 26 | 20 | 24 | 20 |

[1] H' = Shannon Weaver species diversity index

[2] S = Species richness

Table 16. Variation in breeding bird abundance and species richness and diversity indices for various size (ha) openings and varying structure of bordering southern pine.

| Variable | N | Within Opening | Distance from opening (m) | | | |
|---|---|---|---|---|---|---|
| | | | 0-25 | 25-50 | 50-75 | 75-100 |
| | | 0.1-0.2 ha openings[1] | | | | |
| | 2 | | | | | |
| $\bar{x}$ Species | | 1.0 | 2.2 | 0.5 | 1.0 | 1.2 |
| $\bar{x}$ Individuals | | 1.9 | 2.7 | 0.9 | 1.0 | 1.2 |
| H'[a] | | 1.540 | 2.119 | 0.693 | 1.609 | 1.946 |
| S[b] | | 6 | 11 | 2 | 5 | 7 |
| | | 0.1-0.2 ha openings[2] | | | | |
| | 2 | | | | | |
| $\bar{x}$ Species | | 0.5 | 3.0 | 2.4 | 1.9 | 2.9 |
| $\bar{x}$ Individuals | | 0.9 | 3.9 | 2.5 | 2.0 | 3.0 |
| H' | | 0.950 | 2.136 | 2.395 | 1.894 | 2.197 |
| S | | 3 | 11 | 12 | 8 | 11 |
| | | 0.3-0.6 ha openings [3] | | | | |
| | 8 | | | | | |
| $\bar{x}$ Species | | 0.2 | 2.2 | 1.2 | 0.9 | 0.9 |
| $\bar{x}$ Individuals | | 0.2 | 2.6 | 1.2 | 1.1 | 0.9 |
| H' | | 1.330 | 2.305 | 2.118 | 2.246 | 2.372 |
| S | | 4 | 18 | 11 | 11 | 13 |
| | | 0.3-0.6 ha openings[4] | | | | |
| | 5 | | | | | |
| $\bar{x}$ Species | | 1.7 | 3.7 | 2.9 | 2.7 | 2.3 |
| $\bar{x}$ Individuals | | 2.3 | 4.7 | 3.3 | 2.8 | 2.6 |
| H' | | 2.123 | 2.576 | 2:679 | 3.012 | 2.826 |
| S | | 12 | 22 | 17 | 23 | 20 |
| | | 0.3-0.6 ha openings[5] | | | | |
| | 3 | | | | | |
| $\bar{x}$ Species | | 2.0 | 4.3 | 1.9 | 1.6 | 2.2 |
| $\bar{x}$ Individuals | | 2.1 | 5.1 | 2.7 | 2.1 | 2.3 |
| H' | | 2.274 | 3.065 | 2.232 | 2.406 | 2.441 |
| S | | 11 | 26 | 13 | 13 | 13 |

[a] H' = Shannon Weaver diversity index

[b] S = Species richness

[1] Canopy coverage 0.6m-7.5m = 54%, >7.5m = 55%.

[2] Canopy coverage 0.6m-7.5m = 35%, >7.5m = 49%.

[3] Unmanaged, canopy coverage 0.6m-7.5m = 64%, >7.5m = 60%.

[4] Managed, canopy coverage 0.6m-7.5m = 24%, >7.5m = 25%.

[5] Canopy coverage 0.6m-7.5m = 25%, >7.5m = 59%.

Table 17. Avian species detected in each of five transect segments during three censuses of 20 openings partially or totally surrounded by managed and unmanaged southern pine in the Shawnee National Forest, spring 1985 and 1986.

| Species | Within Opening | Distance from opening (m) 0-25 | 25-50 | 50-75 | 75-100 | Total |
|---|---|---|---|---|---|---|
| Acadian flycatcher<br>*Empidonax virescens* |  | 1 |  | 1 | 2 | 4 |
| American crow<br>*Corvus brachyrhynchos* | 5 | 2 |  | 3 |  | 10 |
| American goldfinch<br>*Carduelis tristis* | 7 | 5 | 2 | 2 | 6 | 22 |
| American robin<br>*Turdus migratorius* |  |  | 1 |  |  | 1 |
| Barred owl<br>*Strix varia* | 2 |  |  |  |  | 2 |
| Black-throated green warbler<br>*Dendroica virens* | 1 |  |  |  |  | 1 |
| Blue-gray gnatcatcher<br>*Polioptila caerulea* | 3 | 8 | 6 | 1 | 2 | 20 |
| Blue grosbeak<br>*Guiraca caerulea* | 1 |  |  |  |  | 1 |
| Blue jay<br>*Cyanocitta cristata* |  | 5 | 2 | 5 | 3 | 15 |
| Blue-winged warbler<br>*Vermivora pinus* | 1 | 7 | 3 | 2 | 2 | 15 |
| Brown-headed cowbird<br>*Molothrus ater* | 1 | 7 | 5 | 4 | 1 | 18 |
| Cardinal<br>*Cardinalis cardinalis* | 1 | 8 | 6 | 2 | 3 | 20 |
| Carolina chickadee<br>*Parus carolinensis* |  | 5 | 1 | 1 | 1 | 8 |
| Carolina wren<br>*Thryothorus ludovicianus* |  | 1 |  |  |  | 1 |
| Cerulean warbler<br>*Dendroica cerulea* |  | 2 |  |  | 2 | 4 |

Table 17. Continued.

| Species | Within Opening | Distance from opening (m) | | | | |
|---|---|---|---|---|---|---|
| | | 0-25 | 25-50 | 50-75 | 75-100 | Total |
| Cedar waxwing<br>*Bombycilla cedrorum* | | | | 1 | | 1 |
| Chipping sparrow<br>*Spizella passerina* | 2 | 1 | 1 | | 1 | 5 |
| Common grackle<br>*Quiscalus quiscula* | 2 | 2 | 8 | | | 12 |
| Common yellowthroat<br>*Geothlypis trichas* | 14 | 6 | 1 | 1 | | 22 |
| Downy woodpecker<br>*Picoides pubescens* | | 3 | | 3 | 1 | 7 |
| Eastern bluebird<br>*Sialia sialis* | | | 1 | | | 1 |
| Eastern kingbird<br>*Tyrannus tyrannus* | 1 | | | | | 1 |
| Eastern wood pewee<br>*Contopus virens* | | 1 | | | 1 | 2 |
| Field sparrow<br>*Spizella pusilla* | 10 | 2 | 1 | | | 13 |
| Gray catbird<br>*Dumetella carolinensis* | 1 | | | | | 1 |
| Great-crested flycatcher<br>*Myiarchus crinitus* | | 1 | | 1 | 1 | 3 |
| Hairy woodpecker<br>*Picoides villosus* | 3 | 3 | | | 2 | 8 |
| Hooded warbler<br>*Wilsonia citrina* | | 6 | 5 | 3 | 8 | 22 |
| Indigo bunting<br>*Passerina cyanea* | 10 | 62 | 9 | 8 | 14 | 103 |
| Kentucky warbler<br>*Oporornis formosus* | | 1 | 3 | 1 | 8 | 13 |

Table 17. Continued.

| Species | Within Opening | Distance from opening (m) | | | | |
|---|---|---|---|---|---|---|
| | | 0-25 | 25-50 | 50-75 | 75-100 | Total |
| Mourning dove<br>*Zenaida macroura* | | 3 | | | | 3 |
| Northern oriole<br>*Icterus galbula* | | | | 1 | | 1 |
| Orchard oriole<br>*Icterus spurius* | 2 | | | 1 | 2 | 5 |
| Ovenbird<br>*Seiurus aurocapillus* | | 6 | 8 | 6 | 4 | 24 |
| Parula warbler<br>*Parula americana* | | 1 | | | | 1 |
| Pileated woodpecker<br>*Dryocopus pileatus* | 1 | 1 | 1 | 1 | | 4 |
| Pine warbler<br>*Dendroica pinus* | | 12 | 15 | 10 | 10 | 47 |
| Prairie warbler<br>*Dendroica discolor* | | 7 | 5 | 6 | 5 | 23 |
| Red-bellied woodpecker<br>*Melanerpes carolinus* | | 2 | 1 | 1 | 2 | 6 |
| Red-eyed vireo<br>*Vireo olivaceus* | | 2 | 3 | 4 | 3 | 12 |
| Red-headed woodpecker<br>*Melanerpes erythrocephalus* | | 1 | | | | 1 |
| Red-shouldered hawk<br>*Buteo lineatus* | | 1 | | | 1 | 2 |
| Ruby-throated hummingbird<br>*Archilochus colubris* | 2 | 3 | 2 | | 2 | 9 |
| Rufous-sided towhee<br>*Pipilo erythrophthalmus* | | 16 | 6 | 9 | 4 | 35 |
| Scarlet tanager<br>*Piranga olivacea* | | | 1 | 2 | 1 | 4 |

Table 17. Continued.

| Species | Within Opening | Distance from opening (m) | | | | |
|---|---|---|---|---|---|---|
| | | 0-25 | 25-50 | 50-75 | 75-100 | Total |
| Summer tanager<br>*Piranga rubra* | | 2 | 2 | 3 | | 7 |
| Tufted titmouse<br>*Parus bicolor* | | | | 1 | | 1 |
| Warbling vireo<br>*Vireo gilvus* | | | | 1 | | 1 |
| White breasted nuthatch<br>*Sitta carolinensis* | | | | | 1 | 1 |
| White-eyed vireo<br>*Vireo griseus* | | 4 | 4 | 1 | 2 | 11 |
| Wild turkey<br>*Meleagris gallopavo* | | | | | 1 | 1 |
| Wood thrush<br>*Hylocichla mustelina* | | | | 1 | 1 | 2 |
| Yellow-billed cuckoo<br>*Coccyzus americanus* | 1 | 2 | 1 | 5 | 1 | 10 |
| Yellow-breasted chat<br>*Icteria virens* | 4 | 7 | 4 | 5 | 3 | 23 |
| Yellow-throated vireo<br>*Vireo flavifrons* | | | 3 | | | 3 |
| Yellow-throated warbler<br>*Dendroica dominica* | | 3 | 9 | 4 | 4 | 20 |
| Total | 75 | 212 | 120 | 101 | 105 | 613 |
| Species richness (S) | 22 | 39 | 31 | 34 | 34 | 56 |
| Species diversity (H') | 2.668 | 2.964 | 3.124 | 3.225 | 3.184 | |

Within unmanaged stands, richness was greatest within the edge zone as was diversity, surprisingly. This higher diversity was a result of ovenbirds, and to a lesser extent pine warblers, being most numerous in interior segments, thus lowering the equitability component of the diversity index. The edge was dominated by indigo buntings (36% of individuals), with ovenbirds and pine warblers ranking second.

In contrast to the above, species richness and diversity were lower along opening edges in managed stands. As in unmanaged stands, indigo buntings dominated the edge (30% of individuals), but rufous-sided towhees, prairie warblers, blue-winged warblers, blue-gray gnatcatchers and pine warblers were of secondary importance. Within interior segments, prairie warblers, and indigo buntings were most numerous. Managed pine stands attracted more species, and individuals (Table 16); however, species composition was different than that of unmanaged stands. In contrast too, species richness and diversity in unmanaged stands were lowest within the opening-forest transition zone.

When compared to openings within oak-hickory stands, managed southern pine stands contained approximately the same mean number of species and individuals within interior as well as edge segments. Unmanaged southern pine supported fewer individuals and species, but contained more ovenbirds, which are considered indicators of mature oak-hickory habitat. It should be noted that oak-hickory habitat was generally within 100-200 meters of the sampling transect within southern pine stands. Southern pine is non-native to all but one location in the SNF; plantations are generally found on gentle slopes, ridge tops, and upland stream bottoms.

## Bobwhite

### Distribution

As expected, routes within predominately forested areas produced fewer calls per listening stop than those in less forested areas (Table 18). The mean number of calls recorded in areas >75% forested was only 1.79 compared to 10.41 in more open habitats. In addition, the presence of forest openings did not positively influence the number of calling males in either type of area. In heavily forested habitats with $\geq$ 1 maintained opening, the number of calls heard per stop was 1.74 compared to 1.88 for areas with no nearby openings. In more open habitats, listening stops in areas lacking openings actually had higher call counts (11.32 vs 7.72) than those with 1 or more nearby opening.

### Opening Use

Evidence of quail use consisted of roost sites and tracks in snow during winter, and flushed birds during all seasons. In winter, 21 of 32 sightings were along opening edges, of which 17 were comprised of thick honeysuckle. Because of snow cover in January and February 1985, coveys concentrated along honeysuckle edges. All winter locations were within 400 m of some other non-forested habitat, which generally was another maintained opening.

During the spring sampling period only 13 openings contained birds or sign; all locations were within 400 m of some other non-forested habitat, and 11 were within 100 m.

In summer, quail were generally located in or nearby disturbed openings. All 28 openings with quail were within 400 m of some other non-forested habitat, and 19 of these were within 100 m.

Table 18. Mean number of male bobwhite calls recorded in relation to degree of forestation and presence or absence of nearby forest openings.

| Openings[1] | Forest $\leq$ 75% | Forest > 75% |
|---|---|---|
| 0 | 11.32(65)[a] | 1.88(33)[c] |
| 1-6 | 7.72(22)[b] | 1.74(54)[c] |
|  | 10.41(87) | 1.79(87) |

[1] within 0.5 km radius of listening stop.

[a] sample size in parenthesis; means with same letter not significantly different ($p>0.10$).

Quail were located in 7 openings in the fall; all of which were within 20 meters of some other non-forested habitat; but distance to cropland ranged from 40 to 550 meters. Four openings from which coveys were flushed had been previously disturbed and contained an abundance of seed producing annuals.

## Wild Turkey

### Distribution

The Jonesboro Ranger District had the highest percentage (38.9%) of sightings. Murphysboro Ranger District had the least number of sightings, but the second highest number of birds, most of which were in the Oakwood Bottom Greentree Reservoir area. Vienna and Elizabethtown districts had about an equal number of sightings.

Turkey sightings appeared related to the distribution of managed openings (Table 19 and 20). Percent occurrence of sightings was almost 3 times greater than expected for quarter sections containing $\geq$ 4 openings within a 0.5 km radius and over 1.5 times greater for quarter sections with $\geq$ 4 openings within 1.0 km radius. It should be noted, however, the positive relationship between distribution of openings and turkey sightings may reflect opportunity for sightings as well as turkey abundance.

### Opening Use

Evidence of turkey use consisted of tracks in snow, and scratch marks and/or feathers in spring, summer, and fall; observations were infrequent. Nesting hens were in thick vegetation and those flushed while foraging with broods were in relatively open vegetation or those previously mowed.

Table 19. Reported turkey sightings[1] in the Shawnee National Forest in relation to managed forest openings[2].

| Number of openings within 0.5 km radius | Percent Occurrence of Turkey Sightings (N = 370) | Percent Occurrence of all available locations[3] (N = 3279) |
|---|---|---|
| 0 | 50.8 | 65.6 |
| 1-3 | 32.7 | 28.5 |
| $\geq$ 4 | 16.5 | 5.9 |

[1] By quarter section as reported by successful deer hunters in 1984, U.S. Forest Service personnel, and other cooperators.

[2] $\chi^2 = 84.0$, $P<0.001$ based on goodness-of-fit test.

[3] All potential sighting locations (i.e., quarter sections) in and within 0.5 km of U.S. Forest Service land.

Table 20. Reported turkey sighting[1] in the Shawnee National Forest in relation to managed forest openings[2].

| Number of openings within 1 km radius | Percent Occurrence of Turkey Sightings (N = 370) | Percent Occurrence of all available locations[3] (N = 3279) |
|---|---|---|
| 0 | 24.1 | 43.5 |
| 1-3 | 30.3 | 28.2 |
| $\geq$ 4 | 45.6 | 28.3 |
| | 100.0 | 100.0 |

---

[1] By quarter section as reported by successful deer hunters in 1984, U.S. Forest Service personnel, and other cooperators.

[2] $\chi^2$ = 71.7, $P<0.001$ based on goodness-of-fit test.

[3] All potential sighting locations (i.e. quarter sections) in and within 1 km of U.S. Forest Service land.

During spring and summer, turkeys or their sign were recorded in 13 openings, all of which were within 300 meters of permanent water, most within 150 m. During fall and winter, 25 of 37 openings used were within 150 m of permanent water.

## DISCUSSION

### White-tailed Deer

Maintained forest openings in the SNF were heavily utilized by white-tailed deer. Degree and type of use varied seasonally and with surrounding land use patterns. Unlike northern states (Cross 1963, McCaffery and Creed 1969, McCaffery et al. 1981) where snow accumulation often limits use, deer in southern Illinois made substantial use of openings in winter. This probably reflects lack of suitable cover for bedding and concealment throughout other habitat types, and potential forage in the form of basal rosettes of several herbaceous species as well as honeysuckle along edges. Dalke (1941) and Dunkeson (1955) identified certain forbs and grasses that provided winter food for deer in the Missouri Ozarks, many of which occur in the SNF. Cushwa et al. (1970) noted that anything green in winter has importance as food, especially Japanese honeysuckle.

Total number of trails indicated greatest use of openings in spring; similarly, McCaffery and Creed (1969) reported heaviest use of openings in northern Wisconsin occurred in spring and fall. Spring foraging in openings may, in fact, have been heavier than documented. Greenup began a few weeks prior to sampling, at which time pre-existing tracks implied extensive earlier use. Winter wheat was foraged heavily when available in spring, as was red clover. These two species were also considered important early food sources to deer in the Missouri Ozarks (Korschgen

et al. 1980). Also, new growth of woody plants was utilized extensively in SNF openings. Cushwa et al. (1970) indicated green succulent leaves and stems of herbaceous and woody species were an important spring food source to deer in the southeast. Kalmbacher and Wasko (1977) suggested management of clearings should be aimed at producing forage in early spring.

Deer foraged heavily in openings during summer, with phenology of plant growth determining favored species at any particular time. Selected herbaceous species varied in importance but red clover was obviously preferred when available. Korschgen et al. (1980) reported red clover was the leading item consumed by deer during July in the Missouri Ozarks. As noted by Cuschwa et al. (1970), new growth of woody vegetation was also very important as summer forage. Openings also provided fawn concealment sites; it was not uncommon to flush a fawn in or adjacent to openings, or locate bedsites. The latter were often in grassy areas under or adjacent to patches of sumac, sassafras or blackberry.

Fall utilization was affected by several factors. Generally, foraging was minimal in the absence of cool-season grasses or domestic or native legumes. However, late summer mowing often stimulated new growth in fall. Consequently, deer utilized mowed openings extensively, selecting various herbaceous and woody sprouts for food. Regardless of setting or previous treatment, openings containing cereal grains or domestic legumes were heavily foraged. Other studies have also documented the importance of clover to deer during fall as well as other seasons (Handy and Scharnagel 1961, McGinnes and Ripley 1962, Segelquist and Rogers 1975, McCaffery et al. 1981).

Deer utilized annually treated as well as neglected openings; thus, in a sense, present management could be considered beneficial for white-tailed deer. However, as deer are generalists with respect to many habitat requirements, mismanagement of opening vegetation would be difficult. However, size, shape and density of openings required to optimize deer use of individual openings or affect distribution might vary from present management trends. In the SNF, smaller openings contained more trails and beds per unit area than larger openings and were foraged more uniformly. McCaffery and Creed (1969) found a significant negative correlation between use and opening size; those less than 0.4 ha were utilized most. Patric (1966) indicated openings 0.65 ha or larger might have been the critical size required to increase deer use. Segelquist and Rogers (1975) reported smaller openings were more heavily grazed. Williamson and Hirth (1985) noted, however, that if preferred abundant browse was available, deer would feed in the middle of clear-cuts; this tendency was also evident in the SNF. Even though small openings were more intensively used, deer utilized entire openings regardless of size if preferred forage and/or cover was available.

In addition to size, opening shape was important in determining deer utilization. McCaffery and Creed (1969) noted narrow openings were biologically more efficient per unit area than were larger openings. In the SNF, deer tended to bed and forage in close proximity to the edge of larger openings; but, if preferred food was available, shape and/or size did not affect use.

## Breeding Songbirds

Structural aspects of vegetation influence the distribution of breeding birds (Johnston and Odum 1956, Bond 1957, Shugart and James 1973), and

each seral stage in succession may have a different breeding bird community (Hamilton and Noble 1975, Meyers and Johnson 1978). Birds characteristic of old field and shrublands (Kroodsma 1982) inhabited maintained openings within the SNF, and an increase in species richness and abundance occurred along edges as expected (Lay 1938, McElveen 1979).

Taylor and Taylor (1979) recommended that a variety of opening sizes be maintained to compensate for lack of knowledge about optimum sizes for bird communities. In the SNF, 0.1-0.2 ha openings in mature deciduous forest were not large enough to attract a variety or substantial numbers of opening-dependent species, which would increase the species richness of the forest-opening transition zone. Only one cowbird occurred within the sampled area during 3 samplings of 4 different openings of this smallest size class; similarly, edge associated with 0.3-0.6 ha openings adjacent to unmanaged southern pine stands did not support many cowbirds. However, cowbirds were not uncommon along edges of larger openings. Gates and Gysel (1978) cited predation and cowbird parasitism as the most important factors for nest failures of breeding songbirds.

Robbins (1979) discussed the effects of forest fragmentation on breeding species dependent on large unbroken tracts of forest; most such species were found within the SNF during this study. Kroodsma (1984) examined the effect of edge on breeding forest bird species and observed worm-eating warblers no closer than 250 m from edge habitat. However, worm eating warblers, a species intolerant of forest fragmentation (Whitcomb et al. 1981), were recorded within 50 m of openings during our study. Also, ovenbirds, which are considered forest-interior species, were common in unmanaged southern pine stands even within 25 m of openings. Graber

and Graber (1983) reported the highest breeding density of ovenbirds in southern Illinois was at the edge of a pine plantation.

The present study was not designed or intended to determine impact of forest openings upon population densities of forest-interior obligate species. However, data obtained suggested that present distribution of forest openings and private lands within the SNF are not affecting the presence of area-sensitive forest-interior species (Whitcomb et al. 1981). Furthermore, this situation most likely will not occur due to increases in forested acreage in southern Illinois.

Given the consistent presence of many species considered dependent upon large unbroken blocks of timber, concerns over fragmentation within the SNF may seen unwarranted. But, until densities of area-sensitive species are determined within areas with and without openings, no conclusions can or should be made concerning opening effect on woodland breeding bird populations.

## Bobwhite

Several authors have identified quail management potential within forested areas of the southeast (Goodrum and Reid 1954, Rosene 1969, Arner 1972); but, forest conditions in that region are generally more favorable for quail production than in the Midwest. Based on our data, present opening distribution and/or management within the SNF apparently did not influence abundance of quail, i.e. call counts were similar in areas with and without openings. Nevertheless, quail did utilize individual openings within the SNF. Openings within 400 m of some other non-forested habitat most often contained quail; and, birds were most frequently observed in or heard calling in close proximity to recently disturbed openings. It should be noted that call count routes did not include state-managed cereal grain openings as these were in essentially non-forested areas.

McRae et al. (1979) discovered in southwestern Georgia and northern Florida that oak mast was preferred over legumes by quail when both were available. Thus, the potential may exist for increased quail populations within oak-hickory dominated portions of the SNF. Given the fact that Illinois game harvest data revealed a 50-70% decline in quail populations over the past 25 years (Tetreault 1985), local populations might benefit from opening management.

Recent State management concentrated on establishing food plots; these provided a food supply and soil disturbance opened vegetation contributing brood foraging areas. According to other studies (Bookhout 1958, Triner and Klimstra 1965, Ellis et al. 1969, Buckner and Landers 1979, Dunbar 1981) disturbed sites provided desirable native annual seed producing plants and bare ground 1 year post disturbance; and, by the second and third years, desirable nesting grasses. Klimstra and Roseberry (1975) reported desirable quail nesting conditions in southern Illinois were associated with intermediate rather than early or late successional stages. However, they (1975:18) also noted "that small isolated patches of potential nesting cover located in or near basically nonbreeding habitat, such as cropland or woods, were not especially attractive to nesting birds."

## Wild Turkey

Openings have long been recognized as an important component of turkey habitat (Stoddard 1936, McGinnes and Ripley 1962, Lewis 1964). Sightings confirmed turkeys were often in the vicinity of or within maintained openings in the SNF. Based on turkey hunter kill locations, Price et al. (1984) considered the best habitat for wild turkey in southern Illinois to be forested stands of oak-hickory with agriculture fields and forest openings in proximity.

These results are not unexpected considering openings are currently managed primarily to benefit wild turkey through maintenance of existing vegetation or tame legume establishment (comments by M. Spanel, Wildlife Specialist, U.S.F.S. Harrisburg, Ill.). Legume management varies by district, with seeding rate, inoculation, frequency of mowing, soil conditions, site preparation, and pre-existing vegetation type influencing results. Recent turkey brood studies have emphasized the importance of vegetation open sufficiently for free poult movement (Hurst and Stringer 1975, Healy and Nenno 1983). Data suggest present legume management is not providing structurally desirable habitat for turkeys (Overcash 1987). In some instances, opening herbaceous and/or woody vegetation was sufficiently dense for turkey nesting habitat, but was not open enough for easy brood movement; this was the case in approximately 75% of Jonesboro District openings visited. At such sites, poults were observed only along access trails where vegetation was downed by three-wheeler activity.

## CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Data indicate smaller openings would be more intensively utilized by deer and would have less impact on the distribution of woodland breeding songbirds; thus in the event of new construction, openings should be limited to 0.2-0.5 ha and shaped to enhance soil retention, especially if future disturbance is anticipated. However, a more efficient approach would be to halt further construction of openings. Approximately 1550 openings presently exist within the Forest, but ineffective management in some areas has lessened their importance as critical habitat (i.e. early wild turkey brood habitat). The "more is better" approach to the wildlife opening program obviously has stretched financial resources

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and has detracted from overall management effectiveness, especially within the Jonesboro and Murphysboro districts. It is felt a reduction of 200-300 openings could ensure increased utilization of remaining openings and free up funds so intensive management for quail, early wild turkey brood range, and white-tailed deer could be accomplished. This reduction is recommended fully realizing that potential exists for decreased deer numbers in the future; however, to assume forest openings are solely responsible for deer population fluctuations in southern Illinois would be a mistake. Changing private land use patterns within inholdings along with harvest management are undoubtedly the major factors affecting white-tailed deer abundance.

Present opening density varies greatly within the Forest. If increased utilization of individual openings is desired, then a density of 1-5 other openings (located 200-600 m apart) within a 1.0 km radius (310 ha) should enhance use of a given opening. Given the patchy nature of the SNF, these openings most likely would not be the only other non-forested habitat within 1.0 km. However, if distribution of deer is to be influenced, 5-10% of the area within the surrounding 1.0 km should be maintained in open habitat. Apparently, large clusters of openings and/or adjacent open habitat attracted deer; probably because of increased availability of foraging and bedding sites. This open habitat could include managed openings, old fields, or right-of-ways within 1.0 km. Nixon et al. (1970) recommended 10% of 607-ha management units on public hunting areas be maintained as old fields, which were important feeding areas for deer in Ohio. McCaffery and Creed (1969) suggested 5% open habitat within a management unit was adequate for deer in northern Wisconsin, and Allen and Cromer (1977) recommended 2% of forested areas in West Virginia be maintained as grasses, legumes or grain crops and an additional 5% as

early successional state openings. Private pasture, hayfields, and/or cropland should not be considered in the percentage of open habitat within 1.0 km because of frequent overgrazing, haying, and fall plowing.

Throughout the Vienna and Elizabethtown districts, where dense opening vegetation is uncommon compared to the Jonesboro District, mowing every 2 years would probably suffice in controlling encroachment of woody growth. Woody vegetation provides forage and cover for deer; thus, complete elimination through herbicide use should be avoided. However, unlike present management and excluding that recommended for domestic legumes, only half of the openings within a given compartment should be mowed each year; thus, mowed openings, which provide valuable late summer and early fall forage to deer, would be present within individual compartments every year. Short (1975) felt it important to provide nutritious foods for southern deer in late summer and early fall to insure they entered the late fall stress period in good condition. Mautz (1978) likewise stressed the importance of late summer-early fall fat reserves to the winter survival of northern deer.

Priority should be given to delineation and establishment of quail management areas, especially within the Vienna (compartments 29, 36, 94, 95, and 96) and Elizabethtown (compartments 28, 31, 41, 42, and 43) districts and portions of the Murphysboro District (compartments 4, 7, 49, 50, 61, and 63). High densities of openings in conjunction with extensive southern pine plantations and/or those within 400 m of private agriculture could provide valuable feeding, nesting, or roosting habitat (Overcash 1987).

An intensive management program utilizing discing and burning would be required if the State and Forest Service intend to realize increases

in local quail populations solely through the manipulation of public lands. Management for quail and attempts to establish and maintain desirable turkey brood habitat within Jonesboro District openings would be expensive. But, elimination of undesirable or problem openings and less intensive management via mowing and burning of remaining openings would help offset costs associated with intensive efforts.

Several factors must be considered when managing for quail. If winter food is of primary concern, planting of annual cereal grains followed by 1 year abandonment could produce food supplies and desirable bare ground conditions. In small openings, discing should occur throughout, but in larger (>0.4 ha) openings only a portion should be disced every 2 years and that part disced should be alternated. Thus, a portion of an opening would be in food producing condition and the remainder providing nesting habitat.

If a compartment or group of compartments is designated for quail management, not all openings should be in cereal grain production. Some openings providing primarily nesting habitat might be desirable. Upon delineation of quail management areas, remaining openings need to be visited, vegetation assessed, utility determined, and appropriate management identified. Those SNF openings containing a native-warm season grass component (i.e. little bluestem, broom sedge) were judged to be structurally more desirable for turkey brood use than those dominated by perennial and annual forbs (Overcash 1987). These grasses are also used in nest construction and concealment by quail (Klimstra and Roseberry 1975). If existing opening vegetation is determined desirable and/or a warm-season grass component is present, burning should be used to maintain it. Disturbance should entail only light discing. Small openings should be burned on

a 3-year rotation, but larger (1.0 ha) openings should be partially burned creating adjacent feeding and nesting habitats; Landers (1981:76) noted "insect production within proper foraging cover may be the first limiting factor affecting bobwhite abundance in forested habitat." Hurst (1970) considered burning a valuable tool for establishing quail brood habitat; and noted (1972) small insects were the most important foods eaten by quail chicks 2 to 20 days of age. However, burning an area decreases nesting potential the year of the burn (Simpson 1972); to offset this, year of burning could be staggered among several openings.

Legume production and maintenance is dependent upon mowing. If maximum legume production is desired, mowing twice a year is recommended (Overcash 1987). Deer management should be aimed at providing a variety of vegetation types. Strategically located red clover openings in combination with openings of native vegetation maintained in various stages of early secondary succession (1-4 yrs) through burning or mowing would provide excellent forage and bedding sites for deer.

In instances where woody vegetation detracts from potential wild turkey brood habitat (Lewis 1964), annual mowing would be required to provide desirable habitat for late summer and fall; this condition was readily evident within the Jonesboro and Murphysboro districts. Hurst and Owen (1980) found that mowing caused initial declines in arthropods; but, after 5 weeks they were more numerous on mowed than unmowed plots. Hillestad and Speake (1970) observed hens moving poults, approximately 2 weeks of age, into recently mowed pastures where daily feeding activities occurred for up to 2 weeks. However, they suggested leaving an ecotone between field and forests where early brood movement was concentrated. If protective cover is absent, Hurst and Owen (1980) recommended leaving

an unmowed strip at least 5 m wide along the edge of clearings to provide protective cover, foraging sites for young poults, and nesting habitat for hens. They also suggested alternating portions of this strip could be mowed from year to year to prevent woody encroachment. This method of mowing openings should be incorporated into present management in the SNF. Currently, entire openings are mowed, and most exhibit no intermediate seral stage between forest and opening, unless located in old fields or young plantations. While complete mowing may be the most cost effective method in very small openings (0.1 ha), it is not desirable for wildlife regardless of opening size.

More intensive management of openings comprised of structurally undesirable vegetation could also be accomplished by discing/plowing openings and seeding with orchard grass. Once established, mowing should occur annually and a light discing every 2 years to remove accumulated duff and maintain a grass/forb vegetation type. Healy and Nenno (1983) noted that an orchard grass opening disced to create a grass/forb vegetation type produced as much food for poults as grass/legume management. Several openings within the Jonesboro District had been seeded to orchard grass and were structurally superior to most others observed. This cool-season grass could be valuable, as compared to fire-dependent warm-season grasses, in areas dominated by hardwoods (i.e. Jonesboro District) lacking adjacent private hayfields and pastures.

Openings comprised of undesirable vegetation (i.e. honeysuckle, fescue), bisected by gravel roads used for logging or recreation, or habitually abused by campers and/or off-road vehicles should be dropped from future management. If such openings are considered important and/or provide the only open habitat within an area, renovation or mitigation

of existing conditions should occur. This might include planting fruit trees or shrubs along one or both sides of the roads; a practice that would provide wildlife food and cover as well as reduce opportunities for poaching from vehicles.

Establishment of legumes in fescue openings should not be attempted without complete elimination of this grass; discing in the absence of roundup application did not prevent fescue from dominating openings 1 year post disturbance (Overcash 1987). According to Dunbar (1981) plowing was the only mechanical treatment successful in shifting dominance in old fields to annual and eventually perennial forbs.

The SNF opening management program is valuable to a variety of wildlife species, and its importance as a desirable habitat component should not be underestimated. Overgrazed pastures, frequently cut hayfields, fields that are fall plowed, and/or clearcuts cannot be considered comparable habitat to that provided by maintained openings. Also, hunters can identify them and actually see that an effort is being made to enhance hunting opportunities. Even though providing quality habitat for game species is the primary purpose for opening maintenance, nongame species also benefit.

Beyond their importance to wildlife, openings maintained in areas providing views of unusual rock formations, scenic areas, and/or old growth forest are esthetically pleasing. A relatively large number of openings are dominated by, or contain remnants of, native warm-season grasses such as little bluestem, big bluestem, and Indian grass, often associated with various prairie forbs. These are most prevalent in the Shawnee Hills and Cretaceous Hills divisions of the Vienna and Elizabethtown districts, and in the Southern Till Plain portion of the Murphysboro

District near Lake Kinkaid. Such plant communities are not only esthetically pleasing, but are the remnants of local communities. Several openings within the Cretaceous Hills exhibited flora characteristic of mesic "barren" sites, such openings should be maintained because of their flora content. With advancing secondary succession, lack of burning, and/or intensive agricultural practices, these communities cannot be expected to maintain themselves. Such sites should be identified and maintained through appropriate management strategies; their number could be substantially increased by controlled burning. Their destruction for whatever reason cannot be tolerated as management is inexpensive and quality habitat is provided.

## ACKNOWLEDGEMENTS

This study was conducted by the Cooperative Wildlife Research Laboratory, SIU-C and was financed by the Illinois Department of Conservation as part of Federal Aid Project W-94-R. We wish to especially acknowledge the contributions of James Devereux, former CWRL graduate Assistant, who was involved in project planning and data collection through June 1986. We also appreciate the support and encouragement of James Moak and Floyd Kringer, IDOC, throughout the project. Jack Newton, Jared Garver, and Mike Murphy, IDOC, provided information on opening management and turkey locations. Mike Spanel, Helen Soderburg, Jim McGowen, John Hall, Dave Huggins, and Jay Wittak, U.S. Forest Service, also provided valuable information regarding the opening management program. Sue Stroyles and Doug Robinson, SIU-C, helped with the breeding bird counts, while Bob Massey assisted in a variety of ways during the project.

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Appendix A. Surrounding land use of openings within designated regions of the Shawnee National Forest.

| Variable | N | X̄ | S.D. | MIN | MAX |
|---|---|---|---|---|---|
| EAST REGION | | | | | |
| %Cropland* | 102 | 4.0 | 6.1 | 0.0 | 25.0 |
| %Pasture/hayfield* | 102 | 8.2 | 7.7 | 0.0 | 29.0 |
| %Deciduous* | 102 | 63.4 | 11.8 | 36.0 | 89.0 |
| %Coniferous* | 102 | 18.8 | 12.7 | 1.0 | 57.0 |
| %Open habitat* | 102 | 5.7 | 4.4 | 1.0 | 25.0 |
| Distance to nearest non-forested habitat | 103 | 110.2 | 111.7 | 0.0 | 492.0 |
| #Openings* | 103 | 6.3 | 3.3 | 1.0 | 15.0 |
| MIDDLE REGION | | | | | |
| %Cropland | 30 | 5.2 | 5.8 | 0.0 | 22.0 |
| %Pasture/hayfield | 30 | 16.6 | 12.6 | 0.0 | 42.0 |
| %Deciduous | 30 | 56.1 | 12.2 | 36.0 | 83.0 |
| %Coniferous | 30 | 16.2 | 8.2 | 4.0 | 37.0 |
| %Open habitat | 30 | 4.9 | 3.9 | 1.0 | 19.0 |
| Distance to nearest non-forested habitat | 30 | 63.6 | 72.4 | 0.0 | 276.0 |
| #Openings | 30 | 5.9 | 2.4 | 1.0 | 10.0 |
| NORTHWEST REGION | | | | | |
| %Cropland | 52 | 4.8 | 3.8 | 0.0 | 15.0 |
| %Pasture/hayfield | 52 | 6.0 | 6.0 | 0.0 | 18.0 |
| %Deciduous | 52 | 78.0 | 9.0 | 60.0 | 95.0 |
| %Coniferous | 52 | 4.9 | 4.8 | 0.0 | 26.0 |
| %Open habitat | 52 | 4.9 | 4.0 | 1.0 | 18.0 |
| Distance to nearest non-forested habitat | 52 | 65.3 | 72.7 | 0.0 | 216.0 |
| #Openings | 52 | 9.2 | 5.4 | 1.0 | 20.0 |
| OAKWOOD BOTTOMS REGION | | | | | |
| %Cropland | 9 | 9.0 | 12.3 | 0.0 | 30.0 |
| %Pasture/hayfield | 9 | 0.1 | 0.3 | 0.0 | 1.0 |
| %Deciduous | 9 | 85.0 | 16.2 | 56.0 | 99.0 |
| %Coniferous | 9 | 0.8 | 1.6 | 0.0 | 4.0 |
| %Open habitat | 9 | 5.1 | 3.4 | 1.0 | 11.0 |
| Distance to nearest non-forested habitat | 9 | 131.4 | 110.2 | 0.0 | 360.0 |
| #Openings | 9 | 2.2 | 0.8 | 1.0 | 3.0 |

Appendix A. Continued

| Variable | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|
| SOUTHWEST REGION | | | | | |
| %Cropland | 46 | 1.1 | 2.8 | 0.0 | 16.0 |
| %Pasture/hayfield | 46 | 0.8 | 1.8 | 0.0 | 10.0 |
| %Deciduous | 46 | 92.1 | 5.8 | 70.0 | 100.0 |
| %Coniferous | 46 | 1.9 | 2.3 | 0.0 | 12.0 |
| %Open habitat | 46 | 4.4 | 3.4 | 0.0 | 15.0 |
| Distance to nearest non-forested habitat | 46 | 88.5 | 95.6 | 0.0 | 372.0 |
| #Openings | 46 | 7.3 | 4.1 | 0.0 | 15.0 |

*Within a 1.0 km radius

Appendix B. White-tailed deer utilization of openings by season, Shawnee National Forest.

| INDEX | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|
| WINTER | | | | | |
| Total trails | 240 | 3.0 | 2.4 | 0.0 | 14.0 |
| Total beds | 240 | 1.1 | 2.1 | 0.0 | 12.0 |
| SPRING | | | | | |
| Total trails | 240 | 3.4 | 3.1 | 0.0 | 20.0 |
| Total beds | 240 | 0.2 | 0.7 | 0.0 | 6.0 |
| Percent plots foraged | 240 | 8.8 | 8.1 | 0.0 | 36.5 |
| SUMMER | | | | | |
| Total trails | 215 | 1.8 | 1.7 | 0.0 | 8.0 |
| Total beds | 215 | 0.6 | 1.2 | 0.0 | 8.0 |
| Percent plots foraged | 215 | 12.5 | 13.3 | 0.0 | 93.3 |
| FALL | | | | | |
| Total trails | 233 | 2.1 | 1.8 | 0.0 | 14.0 |
| Total beds | 233 | 0.7 | 1.4 | 0.0 | 9.0 |
| Percent plots foraged | 233 | 12.2 | 16.1 | 0.0 | 94.7 |

Appendix C. White-tailed deer seasonal utilization of openings by region of the Shawnee National Forest.

| INDEX | SEASON | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| EAST REGION | | | | | | |
| Total trails | Winter | 103 | 2.2 | 1.9 | 0.0 | 11.0 |
| Total beds | Winter | 103 | 0.0 | 0.3 | 0.0 | 3.0 |
| Total trails | Spring | 103 | 2.3 | 1.7 | 0.0 | 7.0 |
| Total beds | Spring | 103 | 0.2 | 0.7 | 0.0 | 4.0 |
| Percent plots foraged | Spring | 103 | 12.8 | 7.6 | 0.0 | 36.5 |
| Total trails | Summer | 79 | 1.6 | 1.3 | 0.0 | 6.0 |
| Total beds | Summer | 79 | 0.7 | 1.2 | 0.0 | 8.0 |
| Percent plots foraged | Summer | 79 | 15.4 | 11.6 | 1.8 | 62.7 |
| Total trails | Fall | 102 | 2.2 | 1.6 | 0.0 | 8.0 |
| Total beds | Fall | 102 | 0.9 | 1.6 | 0.0 | 9.0 |
| Percent plots foraged | Fall | 102 | 12.3 | 11.6 | 0.0 | 62.2 |
| MIDDLE REGION | | | | | | |
| Total trails | Winter | 30 | 2.7 | 2.0 | 0.0 | 9.0 |
| Total beds | Winter | 30 | 0.0 | 0.2 | 0.0 | 1.0 |
| Total trails | Spring | 30 | 2.0 | 1.6 | 0.0 | 6.0 |
| Total beds | Spring | 30 | 0.3 | 1.2 | 0.0 | 6.0 |
| Percent plots foraged | Spring | 30 | 13.4 | 7.9 | 2.9 | 28.6 |
| Total trails | Summer | 28 | 2.6 | 1.7 | 0.0 | 6.0 |
| Total beds | Summer | 28 | 1.4 | 1.6 | 0.0 | 6.0 |
| Percent plots foraged | Summer | 28 | 18.5 | 10.5 | 0.0 | 52.6 |
| Total trails | Fall | 30 | 3.0 | 2.8 | 0.0 | 14.0 |
| Total beds | Fall | 30 | 0.9 | 1.6 | 0.0 | 6.0 |
| Percent plots foraged | Fall | 30 | 30.3 | 24.5 | 5.5 | 94.7 |
| NORTHWEST REGION | | | | | | |
| Total trails | Winter | 52 | 4.5 | 2.7 | 0.0 | 14.0 |
| Total beds | Winter | 52 | 3.2 | 3.0 | 0.0 | 12.0 |
| Total trails | Spring | 53 | 6.4 | 4.1 | 0.0 | 20.0 |
| Total beds | Spring | 53 | 0.2 | 0.7 | 0.0 | 4.0 |
| Percent plots foraged | Spring | 53 | 5.1 | 6.1 | 0.0 | 25.0 |
| Total trails | Summer | 53 | 2.2 | 2.2 | 0.0 | 8.0 |
| Total beds | Summer | 53 | 0.6 | 1.1 | 0.0 | 0.4 |
| Percent plots foraged | Summer | 53 | 10.2 | 18.5 | 0.0 | 93.0 |
| Total trails | Fall | 52 | 2.4 | 1.7 | 0.0 | 8.0 |
| Total beds | Fall | 52 | 0.5 | 1.1 | 0.0 | 5.0 |
| Percent plots foraged | Fall | 52 | 10.8 | 16.4 | 0.0 | 68.2 |

Appendix C. Continued.

| INDEX | SEASON | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| OAKWOOD BOTTOMS REGION | | | | | | |
| Total trails | Winter | 9 | 2.6 | 2.4 | 0.0 | 6.0 |
| Total beds | Winter | 9 | 0.7 | 1.3 | 0.0 | 4.0 |
| Total trails | Spring | 9 | 2.2 | 2.1 | 0.0 | 6.0 |
| Total beds | Spring | 9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent plots foraged | Spring | 9 | 1.5 | 2.3 | 0.0 | 5.9 |
| Total trails | Summer | 9 | 0.3 | 0.7 | 0.0 | 2.0 |
| Total beds | Summer | 9 | 0.3 | 0.7 | 0.0 | 2.0 |
| Percent plots foraged | Summer | 9 | 7.5 | 8.9 | 0.0 | 23.5 |
| Total trails | Fall | 5 | 0.8 | 1.3 | 0.0 | 3.0 |
| Total beds | Fall | 5 | 0.6 | 1.3 | 0.0 | 3.0 |
| Percent plots foraged | Fall | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| SOUTHWEST REGION | | | | | | |
| Total trails | Winter | 46 | 3.5 | 2.2 | 0.0 | 9.0 |
| Total beds | Winter | 46 | 1.8 | 1.8 | 0.0 | 6.0 |
| Total trails | Spring | 45 | 3.7 | 2.7 | 0.0 | 12.0 |
| Total beds | Spring | 45 | 0.1 | 0.5 | 0.0 | 3.0 |
| Percent plots foraged | Spring | 45 | 2.3 | 4.1 | 0.0 | 19.2 |
| Total trails | Summer | 46 | 1.2 | 1.2 | 0.0 | 4.0 |
| Total beds | Summer | 46 | 0.0 | 0.2 | 0.0 | 1.0 |
| Percent plots foraged | Summer | 46 | 7.3 | 7.7 | 0.0 | 33.3 |
| Total trails | Fall | 44 | 1.3 | 1.3 | 0.0 | 5.0 |
| Total beds | Fall | 44 | 0.1 | 0.4 | 0.0 | 2.0 |
| Percent plots foraged | Fall | 44 | 2.5 | 4.1 | 0.0 | 15.0 |

Appendix D1. White-tailed deer seasonal utilization of openings by size (ha) class, east region Shawnee National Forest.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| WINTER | | | | | | |
| | 0.1-0.2 | 12 | 1.3 | 1.3 | 0.0 | 4.0 |
| | 0.3-0.5 | 47 | 1.8 | 1.3 | 0.0 | 5.0 |
| | 0.6-0.9 | 28 | 2.5 | 2.0 | 0.0 | 8.0 |
| Total trails | ≥ 1.0 | 16 | 3.3 | 3.0 | 0.0 | 11.0 |
| | 0.1-0.2 | 12 | 7.1 | 7.5 | 0.0 | 20.0 |
| | 0.3-0.5 | 47 | 4.8 | 3.4 | 0.0 | 13.3 |
| Trails per | 0.6-0.9 | 28 | 3.7 | 2.8 | 0.0 | 11.4 |
| unit area | ≥ 1.0 | 16 | 2.8 | 2.5 | 0.0 | 8.2 |
| | 0.1-0.2 | 12 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.3-0.5 | 47 | 0.0 | 0.1 | 0.0 | 1.0 |
| | 0.6-0.9 | 28 | 0.0 | 0.2 | 0.0 | 1.0 |
| Total beds | ≥ 1.0 | 16 | 0.2 | 0.8 | 0.0 | 3.0 |
| | 0.1-0.2 | 12 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.3-0.5 | 47 | 0.0 | 0.3 | 0.0 | 2.0 |
| Beds per | 0.6-0.9 | 28 | 0.1 | 0.3 | 0.0 | 1.4 |
| unit area | ≥ 1.0 | 16 | 0.2 | 0.7 | 0.0 | 2.7 |
| SPRING | | | | | | |
| | 0.1-0.2 | 12 | 1.5 | 1.1 | 0.0 | 3.0 |
| | 0.3-0.5 | 47 | 2.3 | 1.6 | 0.0 | 6.0 |
| | 0.6-0.9 | 28 | 2.4 | 1.9 | 0.0 | 6.0 |
| Total trails | ≥ 1.0 | 16 | 3.1 | 1.9 | 0.0 | 7.0 |
| | 0.1-0.2 | 12 | 7.9 | 5.4 | 0.0 | 15.0 |
| | 0.3-0.5 | 47 | 6.0 | 4.6 | 0.0 | 20.0 |
| Trails per | 0.6-0.9 | 28 | 3.5 | 2.7 | 0.0 | 10.0 |
| unit area | ≥ 1.0 | 16 | 2.7 | 1.6 | 0.0 | 5.8 |
| | 0.1-0.2 | 12 | 0.1 | 0.3 | 0.0 | 1.0 |
| | 0.3-0.5 | 47 | 0.2 | 0.6 | 0.0 | 4.0 |
| | 0.6-0.9 | 28 | 0.2 | 0.6 | 0.0 | 2.0 |
| Total beds | ≥ 1.0 | 16 | 0.4 | 1.0 | 0.0 | 3.0 |
| | 0.1-0.2 | 12 | 0.4 | 1.4 | 0.0 | 5.0 |
| | 0.3-0.5 | 47 | 0.6 | 2.1 | 0.0 | 13.3 |
| Beds per | 0.6-0.9 | 28 | 0.3 | 0.8 | 0.0 | 3.3 |
| unit area | ≥ 1.0 | 16 | 0.4 | 0.9 | 0.0 | 2.7 |

Appendix D1. Continued.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| Percent plots foraged | 0.1-0.2 | 12 | 14.1 | 8.9 | 0.0 | 33.3 |
| | 0.3-0.5 | 47 | 13.9 | 8.6 | 0.0 | 36.5 |
| | 0.6-0.9 | 28 | 11.3 | 5.2 | 0.0 | 25.0 |
| | ≥ 1.0 | 16 | 11.2 | 7.0 | 1.7 | 26.7 |
| SUMMER | | | | | | |
| Total trails | 0.1-0.2 | 9 | 0.8 | 0.4 | 0.0 | 1.0 |
| | 0.3-0.5 | 40 | 1.4 | 1.1 | 0.0 | 4.0 |
| | 0.6-0.9 | 18 | 1.8 | 1.2 | 0.0 | 4.0 |
| | ≥ 1.0 | 12 | 2.7 | 2.0 | 0.0 | 6.0 |
| Trails per unit area | 0.1-0.2 | 9 | 4.4 | 3.0 | 0.0 | 10.0 |
| | 0.3-0.5 | 40 | 3.7 | 2.9 | 0.0 | 10.0 |
| | 0.6-0.9 | 18 | 2.6 | 1.7 | 0.0 | 5.0 |
| | ≥ 1.0 | 12 | 2.4 | 1.7 | 0.0 | 5.5 |
| Total beds | 0.1-0.2 | 9 | 0.2 | 0.7 | 0.0 | 2.0 |
| | 0.3-0.5 | 40 | 0.8 | 1.5 | 0.0 | 8.0 |
| | 0.6-0.9 | 18 | 0.6 | 0.8 | 0.0 | 2.0 |
| | ≥ 1.0 | 12 | 0.9 | 1.0 | 0.0 | 3.0 |
| Beds per unit area | 0.1-0.2 | 9 | 1.1 | 3.3 | 0.0 | 10.0 |
| | 0.3-0.5 | 40 | 2.0 | 3.4 | 0.0 | 16.0 |
| | 0.6-0.9 | 18 | 0.8 | 1.1 | 0.0 | 3.3 |
| | ≥ 1.0 | 12 | 0.8 | 0.8 | 0.0 | 2.1 |
| Percent plots foraged | 0.1-0.2 | 9 | 12.1 | 4.9 | 5.6 | 20.0 |
| | 0.3-0.5 | 40 | 16.4 | 12.5 | 3.4 | 62.7 |
| | 0.6-0.9 | 18 | 12.2 | 5.9 | 1.8 | 25.0 |
| | ≥ 1.0 | 12 | 19.7 | 16.6 | 5.2 | 55.0 |
| FALL | | | | | | |
| Total trails | 0.1-0.2 | 12 | 1.4 | 1.0 | 0.0 | 3.0 |
| | 0.3-0.5 | 47 | 1.8 | 1.3 | 0.0 | 5.0 |
| | 0.6-0.9 | 27 | 2.1 | 1.3 | 0.0 | 4.0 |
| | ≥ 1.0 | 16 | 3.8 | 2.0 | 1.0 | 8.0 |
| Trails per unit area | 0.1-0.2 | 12 | 8.8 | 8.0 | 0.0 | 30.0 |
| | 0.3-0.5 | 47 | 4.8 | 3.5 | 0.0 | 13.3 |
| | 0.6-0.9 | 27 | 3.0 | 2.0 | 0.0 | 6.7 |
| | ≥ 1.0 | 16 | 3.3 | 1.7 | 1.0 | 6.7 |

Appendix D1. Continued.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| Total beds | 0.1-0.2 | 12 | 0.3 | 0.6 | 0.0 | 2.0 |
| | 0.3-0.5 | 47 | 0.7 | 1.6 | 0.0 | 9.0 |
| | 0.6-0.9 | 27 | 1.1 | 1.6 | 0.0 | 5.0 |
| | $\geq$ 1.0 | 16 | 1.8 | 1.9 | 0.0 | 5.0 |
| Beds per unit area | 0.1-0.2 | 12 | 1.3 | 3.1 | 0.0 | 10.0 |
| | 0.3-0.5 | 47 | 1.9 | 3.5 | 0.0 | 18.0 |
| | 0.6-0.9 | 27 | 1.5 | 2.2 | 0.0 | 6.7 |
| | $\geq$ 1.0 | 16 | 1.5 | 1.6 | 0.0 | 4.5 |
| Percent plots foraged | 0.1-0.2 | 12 | 11.8 | 12.5 | 0.0 | 36.4 |
| | 0.3-0.5 | 47 | 12.7 | 10.0 | 0.0 | 50.0 |
| | 0.6-0.9 | 27 | 10.9 | 12.8 | 0.0 | 62.2 |
| | $\geq$ 1.0 | 16 | 13.7 | 14.0 | 3.1 | 51.2 |

Appendix D2. White-tailed deer seasonal utilization of openings by size (ha) class, middle region Shawnee National Forest.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| WINTER | | | | | | |
| Total trails | 0.1-0.2 | 11 | 2.6 | 1.6 | 0.0 | 5.0 |
| | 0.3-0.5 | 14 | 2.9 | 2.3 | 0.0 | 9.0 |
| | 0.6-0.9 | 3 | 1.0 | 1.7 | 0.0 | 3.0 |
| | ≥ 1.0 | 2 | 4.0 | 0.0 | 4.0 | 4.0 |
| Trails per unit area | 0.1-0.2 | 11 | 13.6 | 7.8 | 0.0 | 25.0 |
| | 0.3-0.5 | 14 | 8.0 | 7.4 | 0.0 | 30.0 |
| | 0.6-0.9 | 3 | 1.3 | 2.2 | 0.0 | 3.8 |
| | ≥ 1.0 | 2 | 2.9 | 1.0 | 2.2 | 3.6 |
| Total beds | 0.1-0.2 | 11 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.3-0.5 | 14 | 0.1 | 0.3 | 0.0 | 1.0 |
| | 0.6-0.9 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 1.0 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Beds per unit area | 0.1-0.2 | 11 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.3-0.5 | 14 | 0.2 | 0.9 | 0.0 | 3.3 |
| | 0.6-0.9 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 1.0 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| SPRING | | | | | | |
| Total trails | 0.1-0.2 | 11 | 1.6 | 1.4 | 0.0 | 4.0 |
| | 0.3-0.5 | 14 | 2.3 | 1.8 | 0.0 | 6.0 |
| | 0.6-0.9 | 3 | 1.7 | 1.5 | 0.0 | 3.0 |
| | ≥ 1.0 | 2 | 2.5 | 2.1 | 1.0 | 4.0 |
| Trails per unit area | 0.1-0.2 | 11 | 8.6 | 7.1 | 0.0 | 20.0 |
| | 0.3-0.5 | 14 | 6.2 | 5.8 | 0.0 | 20.0 |
| | 0.6-0.9 | 3 | 2.1 | 1.9 | 0.0 | 3.8 |
| | ≥ 1.0 | 2 | 2.1 | 2.2 | 0.6 | 3.6 |
| Total beds | 0.1-0.2 | 11 | 0.2 | 0.6 | 0.0 | 2.0 |
| | 0.3-0.5 | 14 | 0.1 | 0.3 | 0.0 | 1.0 |
| | 0.6-0.9 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 1.0 | 2 | 3.5 | 3.5 | 1.0 | 6.0 |
| Beds per unit area | 0.1-0.2 | 11 | 0.9 | 3.0 | 0.0 | 10.0 |
| | 0.3-0.5 | 14 | 0.1 | 0.5 | 0.0 | 2.0 |
| | 0.6-0.9 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 1.0 | 2 | 2.1 | 1.7 | 0.9 | 3.3 |

Appendix D2. Continued.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| Percent plots foraged | 0.1-0.2 | 11 | 11.4 | 8.3 | 2.9 | 27.3 |
| | 0.3-0.5 | 14 | 14.7 | 7.4 | 5.2 | 28.6 |
| | 0.6-0.9 | 3 | 12.3 | 6.0 | 7.1 | 18.8 |
| | ≥ 1.0 | 2 | 18.1 | 14.1 | 8.1 | 28.0 |
| SUMMER | | | | | | |
| Total trails | 0.1-0.2 | 10 | 1.9 | 1.0 | 0.0 | 3.0 |
| | 0.3-0.5 | 13 | 2.7 | 1.7 | 1.0 | 6.0 |
| | 0.6-0.9 | 3 | 3.0 | 2.0 | 1.0 | 5.0 |
| | ≥ 1.0 | 2 | 5.5 | 0.7 | 5.0 | 6.0 |
| Trails per unit area | 0.1-0.2 | 10 | 10.0 | 4.7 | 0.0 | 15.0 |
| | 0.3-0.5 | 13 | 6.8 | 3.8 | 2.5 | 13.3 |
| | 0.6-0.9 | 3 | 3.9 | 2.3 | 1.7 | 6.3 |
| | ≥ 1.0 | 2 | 3.9 | 0.9 | 3.3 | 4.5 |
| Total beds | 0.1-0.2 | 10 | 1.5 | 1.8 | 0.0 | 6.0 |
| | 0.3-0.5 | 13 | 0.8 | 0.9 | 0.0 | 2.0 |
| | 0.6-0.9 | 3 | 1.3 | 1.5 | 0.0 | 3.0 |
| | ≥ 1.0 | 2 | 4.5 | 2.1 | 3.0 | 6.0 |
| Beds per unit area | 0.1-0.2 | 10 | 8.0 | 8.9 | 0.0 | 30.0 |
| | 0.3-0.5 | 13 | 2.0 | 2.4 | 0.0 | 6.7 |
| | 0.6-0.9 | 3 | 1.7 | 1.9 | 0.0 | 3.8 |
| | ≥ 1.0 | 2 | 3.0 | 0.4 | 2.7 | 3.3 |
| Percent plots foraged | 0.1-0.2 | 10 | 22.0 | 12.9 | 4.8 | 52.6 |
| | 0.3-0.5 | 13 | 15.6 | 8.7 | 0.0 | 33.3 |
| | 0.6-0.9 | 3 | 16.5 | 10.3 | 10.0 | 28.4 |
| | ≥ 1.0 | 2 | 21.9 | 9.3 | 15.3 | 28.4 |
| FALL | | | | | | |
| Total trails | 0.1-0.2 | 11 | 2.1 | 1.5 | 0.0 | 5.0 |
| | 0.3-0.5 | 14 | 3.1 | 2.1 | 1.0 | 7.0 |
| | 0.6-0.9 | 3 | 1.3 | 0.6 | 1.0 | 2.0 |
| | ≥ 1.0 | 2 | 9.0 | 7.1 | 4.0 | 14.0 |
| Trails per unit area | 0.1-0.2 | 11 | 11.8 | 10.0 | 0.0 | 30.0 |
| | 0.3-0.5 | 14 | 7.9 | 5.1 | 2.5 | 16.7 |
| | 0.6-0.9 | 3 | 1.8 | 0.6 | 1.3 | 2.5 |
| | ≥ 1.0 | 2 | 5.7 | 2.9 | 3.6 | 7.8 |

Appendix D2. Continued.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| Total beds | 0.1-0.2 | 11 | 0.5 | 0.9 | 0.0 | 3.0 |
| | 0.3-0.5 | 14 | 1.0 | 1.6 | 0.0 | 5.0 |
| | 0.6-0.9 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 1.0 | 2 | 4.0 | 2.8 | 2.0 | 6.0 |
| Beds per unit area | 0.1-0.2 | 11 | 2.7 | 4.7 | 0.0 | 15.0 |
| | 0.3-0.5 | 14 | 2.6 | 4.1 | 0.0 | 13.3 |
| | 0.6-0.9 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 1.0 | 2 | 2.6 | 1.1 | 1.8 | 3.3 |
| Percent plots foraged | 0.1-0.2 | 11 | 41.1 | 32.0 | 7.3 | 94.7 |
| | 0.3-0.5 | 14 | 26.0 | 18.0 | 5.5 | 67.6 |
| | 0.6-0.9 | 3 | 17.8 | 13.4 | 9.4 | 33.3 |
| | ≥ 1.0 | 2 | 20.3 | 20.9 | 5.5 | 35.1 |

Appendix D3. White-tailed deer seasonal utilization of openings by size (ha) class, northwest region Shawnee National Forest.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| WINTER | | | | | | |
| Total trails | 0.1-0.2 | 19 | 3.5 | 1.8 | 0.0 | 7.0 |
| | 0.3-0.5 | 28 | 4.9 | 3.1 | 0.0 | 14.0 |
| | 0.6-0.9 | 4 | 6.8 | 2.2 | 5.0 | 10.0 |
| | ≥ 1.0 | 1 | 5.0 | | | |
| Trails per unit area | 0.1-0.2 | 19 | 18.9 | 9.9 | 0.0 | 35.0 |
| | 0.3-0.5 | 28 | 12.6 | 6.8 | 0.0 | 28.0 |
| | 0.6-0.9 | 4 | 9.2 | 2.9 | 5.6 | 12.5 |
| | ≥ 1.0 | 1 | 5.0 | | | |
| Total beds | 0.1-0.2 | 19 | 2.1 | 2.3 | 0.0 | 6.0 |
| | 0.3-0.5 | 28 | 3.3 | 2.6 | 0.0 | 10.0 |
| | 0.6-0.9 | 4 | 9.0 | 2.2 | 7.0 | 12.0 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| Beds per unit area | 0.1-0.2 | 19 | 11.1 | 12.2 | 0.0 | 30.0 |
| | 0.3-0.5 | 28 | 8.8 | 7.4 | 0.0 | 33.3 |
| | 0.6-0.9 | 4 | 12.0 | 2.1 | 10.0 | 15.0 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| SPRING | | | | | | |
| Total trails | 0.1-0.2 | 19 | 4.4 | 2.4 | 0.0 | 10.0 |
| | 0.3-0.5 | 29 | 7.1 | 4.3 | 1.0 | 20.0 |
| | 0.6-0.9 | 4 | 9.3 | 4.6 | 6.0 | 16.0 |
| | ≥ 1.0 | 1 | 14.0 | | | |
| Trails per unit area | 0.1-0.2 | 19 | 23.9 | 14.3 | 0.0 | 60.0 |
| | 0.3-0.5 | 29 | 19.0 | 9.7 | 2.0 | 40.0 |
| | 0.6-0.9 | 4 | 12.4 | 5.5 | 6.7 | 20.0 |
| | ≥ 1.0 | 1 | 14.0 | | | |
| Total beds | 0.1-0.2 | 19 | 0.2 | 0.5 | 0.0 | 2.0 |
| | 0.3-0.5 | 29 | 0.0 | 0.2 | 0.0 | 1.0 |
| | 0.6-0.9 | 4 | 1.5 | 1.9 | 0.0 | 4.0 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| Beds per unit area | 0.1-0.2 | 19 | 0.8 | 2.5 | 0.0 | 10.0 |
| | 0.3-0.5 | 29 | 0.1 | 0.4 | 0.0 | 2.0 |
| | 0.6-0.9 | 4 | 2.1 | 2.5 | 0.0 | 5.0 |
| | ≥ 1.0 | 1 | 0.0 | | | |

Appendix D3. Continued.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| Percent plots foraged | 0.1-0.2 | 19 | 6.0 | 7.2 | 0.0 | 25.0 |
| | 0.3-0.5 | 29 | 4.8 | 5.5 | 0.0 | 18.6 |
| | 0.6-0.9 | 4 | 4.8 | 6.5 | 0.0 | 14.3 |
| | $\geq$ 1.0 | 1 | 0.0 | | | |
| SUMMER | | | | | | |
| Total trails | 0.1-0.2 | 19 | 1.6 | 1.7 | 0.0 | 5.0 |
| | 0.3-0.5 | 29 | 2.6 | 2.5 | 0.0 | 8.0 |
| | 0.6-0.9 | 4 | 1.8 | 1.5 | 0.0 | 3.0 |
| | $\geq$ 1.0 | 1 | 3.0 | | | |
| Trails per unit area | 0.1-0.2 | 19 | 9.2 | 11.1 | 0.0 | 40.0 |
| | 0.3-0.5 | 29 | 6.9 | 6.0 | 0.0 | 20.0 |
| | 0.6-0.9 | 4 | 2.5 | 2.3 | 0.0 | 5.0 |
| | $\geq$ 1.0 | 1 | 3.0 | | | |
| Total beds | 0.1-0.2 | 19 | 0.7 | 1.2 | 0.0 | 4.0 |
| | 0.3-0.5 | 29 | 0.6 | 1.1 | 0.0 | 4.0 |
| | 0.6-0.9 | 4 | 0.3 | 0.5 | 0.0 | 1.0 |
| | $\geq$ 1.0 | 1 | 0.0 | | | |
| Beds per unit area | 0.1-0.2 | 19 | 4.2 | 6.9 | 0.0 | 20.0 |
| | 0.3-0.5 | 29 | 1.7 | 3.3 | 0.0 | 13.3 |
| | 0.6-0.9 | 4 | 0.3 | 0.6 | 0.0 | 1.3 |
| | $\geq$ 1.0 | 1 | 0.0 | | | |
| Percent plots foraged | 0.1-0.2 | 19 | 18.4 | 29.2 | 0.0 | 93.3 |
| | 0.3-0.5 | 29 | 5.7 | 4.4 | 0.0 | 18.2 |
| | 0.6-0.9 | 4 | 6.2 | 2.2 | 4.1 | 9.0 |
| | $\geq$ 1.0 | 1 | 1.2 | | | |
| FALL | | | | | | |
| Total trails | 0.1-0.2 | 19 | 1.8 | 1.5 | 0.0 | 5.0 |
| | 0.3-0.5 | 28 | 2.6 | 1.9 | 0.0 | 8.0 |
| | 0.6-0.9 | 4 | 3.0 | 0.8 | 2.0 | 4.0 |
| | $\geq$ 1.0 | 1 | 4.0 | | | |
| Trails per unit area | 0.1-0.2 | 19 | 10.8 | 10.3 | 0.0 | 40.0 |
| | 0.3-0.5 | 28 | 6.9 | 4.6 | 0.0 | 16.7 |
| | 0.6-0.9 | 4 | 4.2 | 1.8 | 2.2 | 6.7 |
| | $\geq$ 1.0 | 1 | 4.0 | | | |

Appendix D3. Continued.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| Total beds | 0.1-0.2 | 19 | 0.1 | 0.3 | 0.0 | 1.0 |
| | 0.3-0.5 | 28 | 0.8 | 1.4 | 0.0 | 5.0 |
| | 0.6-0.9 | 4 | 1.0 | 1.2 | 0.0 | 2.0 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| Beds per unit area | 0.1-0.2 | 19 | 0.5 | 1.6 | 0.0 | 5.0 |
| | 0.3-0.5 | 28 | 2.2 | 4.5 | 0.0 | 16.7 |
| | 0.6-0.9 | 4 | 1.3 | 1.6 | 0.0 | 2.9 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| Percent plots foraged | 0.1-0.2 | 19 | 17.6 | 23.2 | 0.0 | 68.2 |
| | 0.3-0.5 | 28 | 7.8 | 9.5 | 0.0 | 31.8 |
| | 0.6-0.9 | 4 | 1.4 | 2.8 | 0.0 | 5.6 |
| | ≥ 1.0 | 1 | 2.4 | | | |

Appendix D4. White-tailed deer seasonal utilization of openings by size (ha) class, Oakwood bottoms region Shawnee National Forest.

| INDEX | SIZE CLASS | N | X̄ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| WINTER | | | | | | |
| Total trails | 0.1-0.2 | 8 | 2.1 | 2.1 | 0.0 | 5.0 |
| | 0.3-0.5 | 1 | 6.0 | | | |
| Trails per unit area | 0.1-0.2 | 8 | 13.1 | 12.2 | 0.0 | 30.0 |
| | 0.3-0.5 | 1 | 20.0 | | | |
| Total beds | 0.1-0.2 | 8 | 0.6 | 1.4 | 0.0 | 4.0 |
| | 0.3-0.5 | 1 | 1.0 | | | |
| Beds per unit area | 0.1-0.2 | 8 | 3.1 | 7.0 | 0.0 | 20.0 |
| | 0.3-0.5 | 1 | 3.3 | | | |
| SPRING | | | | | | |
| Total trails | 0.1-0.2 | 8 | 1.8 | 1.7 | 0.0 | 5.0 |
| | 0.3-0.5 | 1 | 6.0 | | | |
| Trails per unit area | 0.1-0.2 | 8 | 11.3 | 10.9 | 0.0 | 30.0 |
| | 0.3-0.5 | 1 | 20.0 | | | |
| Total beds | 0.1-0.2 | 8 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.3-0.5 | 1 | 0.0 | | | |
| Beds per unit area | 0.1-0.2 | 8 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.3-0.5 | 1 | 0.0 | | | |
| Percent plots foraged | 0.1-0.2 | 8 | 1.3 | 2.4 | 0.0 | 5.9 |
| | 0.3-0.5 | 1 | 3.1 | | | |
| SUMMER | | | | | | |
| Total trails | 0.1-0.2 | 8 | 0.4 | 0.7 | 0.0 | 2.0 |
| | 0.3-0.5 | 1 | 0.0 | | | |
| Trails per unit area | 0.1-0.2 | 8 | 1.9 | 3.7 | 0.0 | 10.0 |
| | 0.3-0.5 | 1 | 0.0 | | | |
| Total beds | 0.1-0.2 | 8 | 0.4 | 0.7 | 0.0 | 2.0 |
| | 0.3-0.5 | 1 | 0.0 | | | |
| Beds per unit area | 0.1-0.2 | 8 | 3.1 | 7.0 | 0.0 | 20.0 |
| | 0.3-0.5 | 1 | 0.0 | | | |
| Percent plots foraged | 0.1-0.2 | 8 | 8.5 | 9.0 | 0.0 | 23.5 |
| | 0.3-0.5 | 1 | 0.0 | | | |

Appendix D4. Continued.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| FALL | | | | | | |
| Total trails | 0.1-0.2 | 4 | 0.8 | 1.5 | 0.0 | 3.0 |
| | 0.3-0.5 | 1 | 1.0 | | | |
| Trails per unit area | 0.1-0.2 | 4 | 3.8 | 7.5 | 0.0 | 15.0 |
| | 0.3-0.5 | 1 | 3.3 | | | |
| Total beds | 0.1-0.2 | 4 | 0.0 | | | |
| | 0.3-0.5 | 1 | 3.0 | | | |
| Beds per unit area | 0.1-0.2 | 4 | 0.0 | | | |
| | 0.3-0.5 | 1 | 10.0 | | | |
| Percent plots foraged | 0.1-0.2 | 4 | 0.0 | | | |
| | 0.3-0.5 | 1 | 0.0 | | | |

Appendix D5. White-tailed deer seasonal utilization of openings by size (ha) class, southwest region Shawnee National Forest.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| WINTER | | | | | | |
| Total trails | 0.1-0.2 | 16 | 2.6 | 1.8 | 0.0 | 5.0 |
| | 0.3-0.5 | 23 | 3.8 | 2.3 | 0.0 | 9.0 |
| | 0.6-0.9 | 6 | 5.3 | 2.1 | 3.0 | 9.0 |
| | ≥ 1.0 | 1 | 1.0 | | | |
| Trails per unit area | 0.1-0.2 | 16 | 14.1 | 8.8 | 0.0 | 25.0 |
| | 0.3-0.5 | 23 | 10.0 | 5.8 | 0.0 | 20.0 |
| | 0.6-0.9 | 6 | 7.7 | 3.1 | 5.0 | 12.9 |
| | ≥ 1.0 | 1 | 0.8 | | | |
| Total beds | 0.1-0.2 | 16 | 1.3 | 1.4 | 0.0 | 4.0 |
| | 0.3-0.5 | 23 | 2.0 | 2.1 | 0.0 | 6.0 |
| | 0.6-0.9 | 6 | 2.7 | 1.2 | 1.0 | 4.0 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| Beds per unit area | 0.1-0.2 | 16 | 6.0 | 7.0 | 0.0 | 20.0 |
| | 0.3-0.5 | 23 | 5.2 | 5.6 | 0.0 | 20.0 |
| | 0.6-0.9 | 6 | 3.7 | 1.3 | 1.7 | 5.0 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| SPRING | | | | | | |
| Total trails | 0.1-0.2 | 16 | 2.6 | 1.5 | 0.0 | 5.0 |
| | 0.3-0.5 | 22 | 4.4 | 2.8 | 1.0 | 12.0 |
| | 0.6-0.9 | 6 | 4.2 | 4.1 | 0.0 | 12.0 |
| | ≥ 1.0 | 1 | 2.0 | | | |
| Trails per unit area | 0.1-0.2 | 16 | 14.1 | 8.4 | 0.0 | 30.0 |
| | 0.3-0.5 | 22 | 11.8 | 7.6 | 2.5 | 30.0 |
| | 0.6-0.9 | 6 | 5.9 | 5.8 | 0.0 | 17.1 |
| | ≥ 1.0 | 1 | 1.7 | | | |
| Total beds | 0.1-0.2 | 16 | 0.3 | 0.8 | 0.0 | 3.0 |
| | 0.3-0.5 | 22 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.6-0.9 | 6 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| Beds per unit area | 0.1-0.2 | 16 | 1.3 | 3.9 | 0.0 | 15.0 |
| | 0.3-0.5 | 22 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.6-0.9 | 6 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| Percent plots foraged | 0.1-0.2 | 16 | 3.4 | 6.1 | 0.0 | 19.2 |
| | 0.3-0.5 | 22 | 1.7 | 2.4 | 0.0 | 6.3 |
| | 0.6-0.9 | 6 | 2.0 | 2.0 | 0.0 | 5.1 |
| | ≥ 1.0 | 1 | 0.0 | | | |

Appendix D5. Continued.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| SUMMER | | | | | | |
| | 0.1-0.2 | 16 | 0.8 | 0.9 | 0.0 | 2.0 |
| | 0.3-0.5 | 23 | 1.3 | 1.2 | 0.0 | 4.0 |
| | 0.6-0.9 | 6 | 2.0 | 1.8 | 0.0 | 4.0 |
| Total trails | ≥ 1.0 | 1 | 2.0 | | | |
| | 0.1-0.2 | 16 | 3.8 | 4.7 | 0.0 | 10.0 |
| | 0.3-0.5 | 23 | 3.4 | 3.1 | 0.0 | 10.0 |
| Trails per unit area | 0.6-0.9 | 6 | 3.2 | 2.8 | 0.0 | 6.7 |
| | ≥ 1.0 | 1 | 1.7 | | | |
| | 0.1-0.2 | 16 | 0.1 | 0.3 | 0.0 | 1.0 |
| | 0.3-0.5 | 23 | 0.0 | 0.2 | 0.0 | 1.0 |
| | 0.6-0.9 | 6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total beds | ≥ 1.0 | 1 | 0.0 | | | |
| | 0.1-0.2 | 16 | 0.3 | 1.3 | 0.0 | 5.0 |
| | 0.3-0.5 | 23 | 0.1 | 0.4 | 0.0 | 2.0 |
| Beds per unit area | 0.6-0.9 | 6 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| | 0.1-0.2 | 16 | 8.6 | 8.4 | 0.0 | 26.9 |
| | 0.3-0.5 | 23 | 6.5 | 8.1 | 0.0 | 33.3 |
| Percent plots foraged | 0.6-0.9 | 6 | 5.5 | 4.2 | 1.1 | 10.8 |
| | ≥ 1.0 | 1 | 14.8 | | | |
| FALL | 0.1-0.2 | 16 | 0.8 | 1.0 | 0.0 | 3.0 |
| | 0.3-0.5 | 21 | 1.5 | 1.4 | 0.0 | 5.0 |
| | 0.6-0.9 | 6 | 2.0 | 1.4 | 0.0 | 4.0 |
| Total trails | ≥ 1.0 | 1 | 0.0 | | | |
| | 0.1-0.2 | 16 | 4.1 | 5.2 | 0.0 | 15.0 |
| | 0.3-0.5 | 21 | 3.9 | 4.0 | 0.0 | 12.5 |
| Trails per unit area | 0.6-0.9 | 6 | 3.1 | 2.4 | 0.0 | 6.7 |
| | ≥ 1.0 | 1 | 0.0 | | | |
| | 0.1-0.2 | 16 | 0.1 | 0.5 | 0.0 | 2.0 |
| | 0.3-0.5 | 21 | 0.1 | 0.3 | 0.0 | 1.0 |
| | 0.6-0.9 | 6 | 0.2 | 0.4 | 0.0 | 1.0 |
| Total beds | ≥ 1.0 | 1 | 1.0 | | | |
| | 0.1-0.2 | 16 | 0.6 | 2.5 | 0.0 | 10.0 |
| | 0.3-0.5 | 21 | 0.3 | 0.9 | 0.0 | 3.3 |
| Beds per unit area | 0.6-0.9 | 6 | 0.3 | 0.7 | 0.0 | 1.7 |
| | ≥ 1.0 | 1 | 0.8 | | | |

Appendix D5. Continued.

| INDEX | SIZE CLASS | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| Percent plots foraged | 0.1-0.2 | 16 | 0.8 | 2.6 | 0.0 | 10.0 |
| | 0.3-0.5 | 21 | 3.5 | 4.8 | 0.0 | 15.0 |
| | 0.6-0.9 | 6 | 4.0 | 4.0 | 0.0 | 9.5 |
| | $\geq$ 1.0 | 1 | 0.0 | | | |

Appendix E1. White-tailed deer seasonal utilization of openings as related to number of openings within a 1.0 km radius, east region Shawnee National Forest.

| INDEX | Number of Openings | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| WINTER | | | | | | |
| Total trails | 0-2 | 10 | 3.0 | 2.9 | 0.0 | 9.0 |
| | 3-5 | 40 | 2.3 | 1.9 | 0.0 | 11.0 |
| | 6-8 | 23 | 2.1 | 1.9 | 0.0 | 8.0 |
| | 9-11 | 25 | 2.0 | 1.5 | 0.0 | 5.0 |
| | ≥ 12 | 5 | 1.0 | 1.2 | 0.0 | 3.0 |
| Total beds | 0-2 | 10 | 0.3 | 0.9 | 0.0 | 3.0 |
| | 3-5 | 40 | 0.0 | 0.2 | 0.0 | 1.0 |
| | 6-8 | 23 | 0.0 | 0.2 | 0.0 | 1.0 |
| | 9-11 | 25 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 12 | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| SPRING | | | | | | |
| Total trails | 0-2 | 10 | 3.3 | 1.9 | 1.0 | 7.0 |
| | 3-5 | 40 | 2.5 | 1.5 | 0.0 | 6.0 |
| | 6-8 | 23 | 1.9 | 2.1 | 0.0 | 6.0 |
| | 9-11 | 25 | 2.1 | 1.6 | 0.0 | 6.0 |
| | ≥ 12 | 5 | 2.2 | 1.3 | 1.0 | 4.0 |
| Total beds | 0-2 | 10 | 0.5 | 1.1 | 0.0 | 3.0 |
| | 3-5 | 40 | 0.2 | 0.5 | 0.0 | 3.0 |
| | 6-8 | 23 | 0.4 | 0.9 | 0.0 | 4.0 |
| | 9-11 | 25 | 0.0 | 0.2 | 0.0 | 1.0 |
| | ≥ 12 | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent plots foraged | 0-2 | 10 | 9.9 | 5.5 | 2.7 | 21.9 |
| | 3-5 | 40 | 11.7 | 6.2 | 0.0 | 24.4 |
| | 6-8 | 23 | 15.0 | 7.5 | 6.7 | 36.5 |
| | 9-11 | 25 | 14.4 | 9.8 | 0.0 | 33.3 |
| | ≥ 12 | 5 | 10.0 | 8.2 | 3.1 | 23.8 |
| SUMMER | | | | | | |
| Total trails | 0-2 | 8 | 1.9 | 2.0 | 0.0 | 6.0 |
| | 3-5 | 27 | 2.1 | 1.4 | 0.0 | 6.0 |
| | 6-8 | 22 | 1.4 | 1.1 | 0.0 | 4.0 |
| | 9-11 | 20 | 1.2 | 1.1 | 0.0 | 4.0 |
| | ≥ 12 | 2 | 1.0 | 0.0 | 1.0 | 1.0 |
| Total beds | 0-2 | 8 | 1.0 | 0.9 | 0.0 | 2.0 |
| | 3-5 | 27 | 0.8 | 1.1 | 0.0 | 3.0 |
| | 6-8 | 22 | 1.1 | 1.8 | 0.0 | 8.0 |
| | 9-11 | 20 | 0.2 | 0.4 | 0.0 | 1.0 |
| | ≥ 12 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |

Appendix E1. Continued.

| INDEX | Number of Openings | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| Percent plots foraged | 0-2 | 8 | 10.2 | 3.6 | 5.2 | 14.3 |
| | 3-5 | 27 | 18.2 | 15.5 | 6.7 | 62.7 |
| | 6-8 | 22 | 12.8 | 8.1 | 1.8 | 40.3 |
| | 9-11 | 20 | 16.8 | 10.5 | 3.4 | 43.3 |
| | ≥ 12 | 2 | 14.3 | 7.3 | 9.1 | 19.4 |
| FALL | | | | | | |
| Total trails | 0-2 | 10 | 2.8 | 2.3 | 0.0 | 8.0 |
| | 3-5 | 39 | 2.2 | 1.6 | 0.0 | 7.0 |
| | 6-8 | 23 | 2.0 | 1.3 | 0.0 | 5.0 |
| | 9-11 | 25 | 1.9 | 1.5 | 0.0 | 5.0 |
| | ≥ 12 | 5 | 2.4 | 1.5 | 0.0 | 4.0 |
| Total beds | 0-2 | 10 | 0.9 | 1.4 | 0.0 | 4.0 |
| | 3-5 | 39 | 0.7 | 1.2 | 0.0 | 5.0 |
| | 6-8 | 23 | 0.9 | 2.1 | 0.0 | 9.0 |
| | 9-11 | 25 | 1.4 | 1.7 | 0.0 | 5.0 |
| | ≥ 12 | 5 | 1.2 | 1.6 | 0.0 | 3.0 |
| Percent plots foraged | 0-2 | 10 | 8.2 | 3.7 | 0.0 | 13.9 |
| | 3-5 | 39 | 15.0 | 14.6 | 0.0 | 62.2 |
| | 6-8 | 23 | 8.6 | 8.5 | 0.0 | 38.6 |
| | 9-11 | 25 | 13.0 | 11.1 | 0.0 | 43.5 |
| | ≥ 12 | 5 | 12.1 | 6.1 | 3.1 | 17.9 |

Appendix E2. White-tailed deer seasonal utilization of openings as related to number of openings within a 1.0 km radius, middle region Shawnee National Forest.

| INDEX | Number of Openings | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| WINTER | | | | | | |
| Total trails | 0-2 | 3 | 3.0 | 1.7 | 1.0 | 4.0 |
| | 3-5 | 5 | 0.8 | 1.3 | 0.0 | 3.0 |
| | 6-8 | 19 | 3.1 | 2.0 | 0.0 | 9.0 |
| | 9-11 | 3 | 3.0 | 2.0 | 1.0 | 5.0 |
| Total beds | 0-2 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 3-5 | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 6-8 | 19 | 0.1 | 0.2 | 0.0 | 1.0 |
| | 9-11 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| SPRING | | | | | | |
| Total trails | 0-2 | 3 | 2.7 | 1.5 | 1.0 | 4.0 |
| | 3-5 | 5 | 1.0 | 1.0 | 0.0 | 2.0 |
| | 6-8 | 19 | 2.2 | 1.8 | 0.0 | 6.0 |
| | 9-11 | 3 | 1.7 | 1.5 | 0.0 | 3.0 |
| Total beds | 0-2 | 3 | 2.3 | 3.2 | 0.0 | 6.0 |
| | 3-5 | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 6-8 | 19 | 0.2 | 0.5 | 0.0 | 2.0 |
| | 9-11 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent plots foraged | 0-2 | 3 | 14.8 | 11.8 | 5.2 | 28.0 |
| | 3-5 | 5 | 17.8 | 6.4 | 11.0 | 26.9 |
| | 6-8 | 19 | 12.6 | 7.9 | 2.9 | 28.6 |
| | 9-11 | 3 | 10.2 | 6.9 | 4.1 | 17.6 |
| SUMMER | | | | | | |
| Total trails | 0-2 | 3 | 3.3 | 2.3 | 2.0 | 6.0 |
| | 3-5 | 5 | 2.6 | 2.1 | 1.0 | 6.0 |
| | 6-8 | 18 | 2.8 | 1.4 | 1.0 | 6.0 |
| | 9-11 | 2 | 0.5 | 0.7 | 0.0 | 1.0 |
| Total beds | 0-2 | 3 | 2.0 | 3.5 | 0.0 | 6.0 |
| | 3-5 | 5 | 0.6 | 0.9 | 0.0 | 2.0 |
| | 6-8 | 18 | 1.6 | 1.5 | 0.0 | 6.0 |
| | 9-11 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent plots foraged | 0-2 | 3 | 17.2 | 10.2 | 8.3 | 28.4 |
| | 3-5 | 5 | 11.0 | 7.3 | 0.0 | 20.0 |
| | 6-8 | 18 | 21.8 | 10.4 | 9.5 | 52.6 |
| | 9-11 | 2 | 9.1 | 6.0 | 4.8 | 13.3 |

Appendix E2. Continued.

| INDEX | Number of Openings | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| FALL | | | | | | |
| | 0-2 | 3 | 7.7 | 6.0 | 2.0 | 14.0 |
| | 3-5 | 5 | 2.6 | 2.2 | 1.0 | 5.0 |
| | 6-8 | 19 | 2.5 | 1.3 | 1.0 | 5.0 |
| Total trails | 9-11 | 3 | 2.0 | 3.5 | 0.0 | 6.0 |
| | 0-2 | 3 | 3.7 | 3.2 | 0.0 | 6.0 |
| | 3-5 | 5 | 0.2 | 0.4 | 0.0 | 1.0 |
| | 6-8 | 19 | 0.8 | 1.1 | 0.0 | 4.0 |
| Total beds | 9-11 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0-2 | 3 | 16.0 | 16.6 | 5.5 | 35.1 |
| | 3-5 | 5 | 21.3 | 15.6 | 8.2 | 42.6 |
| Percent plots foraged | 6-8 | 19 | 35.3 | 26.0 | 5.5 | 94.7 |
| | 9-11 | 3 | 28.6 | 33.8 | 7.3 | 67.6 |

Appendix E3. White-tailed deer seasonal utilization of openings as related to number of openings within a 1.0 km radius, northwest region Shawnee National Forest.

| INDEX | Number of Openings | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| WINTER | | | | | | |
| | 0-2 | 2 | 5.0 | 0.0 | 5.0 | 5.0 |
| | 3-5 | 13 | 3.5 | 1.9 | 0.0 | 7.0 |
| | 6-8 | 17 | 3.5 | 2.2 | 0.0 | 10.0 |
| | 9-11 | 2 | 4.5 | 0.7 | 4.0 | 5.0 |
| Total trails | ≥ 12 | 18 | 6.1 | 3.3 | 0.0 | 14.0 |
| | 0-2 | 2 | 4.0 | 0.0 | 4.0 | 4.0 |
| | 3-5 | 13 | 1.8 | 2.0 | 0.0 | 6.0 |
| | 6-8 | 17 | 2.0 | 3.1 | 0.0 | 12.0 |
| | 9-11 | 2 | 2.5 | 3.5 | 0.0 | 2.5 |
| Total beds | ≥ 12 | 18 | 5.4 | 2.5 | 0.0 | 10.0 |
| SPRING | | | | | | |
| | 0-2 | 3 | 8.0 | 1.7 | 7.0 | 10.0 |
| | 3-5 | 13 | 5.6 | 2.2 | 2.0 | 11.0 |
| | 6-8 | 17 | 5.4 | 3.8 | 0.0 | 16.0 |
| | 9-11 | 2 | 8.5 | 7.8 | 3.0 | 14.0 |
| Total trails | ≥ 12 | 18 | 7.4 | 5.1 | 1.0 | 20.0 |
| | 0-2 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 3-5 | 13 | 0.2 | 0.6 | 0.0 | 2.0 |
| | 6-8 | 17 | 0.2 | 1.0 | 0.0 | 4.0 |
| | 9-11 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total beds | ≥ 12 | 18 | 0.2 | 0.5 | 0.0 | 2.0 |
| | 0-2 | 3 | 7.0 | 6.4 | 0.0 | 12.7 |
| | 3-5 | 13 | 3.2 | 3.8 | 0.0 | 10.8 |
| | 6-8 | 17 | 5.3 | 7.5 | 0.0 | 25.0 |
| Percent plots foraged | 9-11 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 12 | 18 | 6.7 | 6.1 | 0.0 | 18.6 |
| SUMMER | | | | | | |
| | 0-2 | 3 | 3.3 | 1.5 | 2.0 | 5.0 |
| | 3-5 | 13 | 1.8 | 1.6 | 0.0 | 5.0 |
| | 6-8 | 17 | 2.5 | 2.4 | 0.0 | 8.0 |
| | 9-11 | 2 | 1.5 | 2.1 | 0.0 | 3.0 |
| Total trails | ≥ 12 | 18 | 2.2 | 2.5 | 0.0 | 8.0 |
| | 0-2 | 3 | 1.7 | 1.5 | 0.0 | 3.0 |
| | 3-5 | 13 | 0.5 | 1.2 | 0.0 | 4.0 |
| | 6-8 | 17 | 0.7 | 1.3 | 0.0 | 4.0 |
| | 9-11 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total beds | ≥ 12 | 18 | 0.4 | 0.7 | 0.0 | 2.0 |

Appendix E3. Continued.

| INDEX | Number of Openings | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| Percent plots foraged | 0-2 | 3 | 7.0 | 3.4 | 3.6 | 10.3 |
| | 3-5 | 13 | 7.3 | 9.4 | 0.0 | 36.4 |
| | 6-8 | 17 | 18.3 | 30.4 | 0.0 | 93.3 |
| | 9-11 | 2 | 3.0 | 2.5 | 1.2 | 4.8 |
| | ≥ 12 | 18 | 6.1 | 3.9 | 0.0 | 14.0 |
| FALL | | | | | | |
| Total trails | 0-2 | 3 | 3.7 | 0.6 | 3.0 | 4.0 |
| | 3-5 | 13 | 1.7 | 1.5 | 0.0 | 5.0 |
| | 6-8 | 17 | 2.0 | 1.4 | 0.0 | 4.0 |
| | 9-11 | 2 | 2.0 | 2.8 | 0.0 | 4.0 |
| | ≥ 12 | 17 | 3.1 | 2.0 | 0.0 | 8.0 |
| Total beds | 0-2 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 3-5 | 13 | 0.4 | 1.4 | 0.0 | 5.0 |
| | 6-8 | 17 | 0.6 | 1.4 | 0.0 | 5.0 |
| | 9-11 | 2 | 0.5 | 0.7 | 0.0 | 1.0 |
| | ≥ 12 | 17 | 0.6 | 0.7 | 0.0 | 2.0 |
| Percent plots foraged | 0-2 | 3 | 15.1 | 3.4 | 11.5 | 18.3 |
| | 3-5 | 13 | 12.2 | 7.4 | 0.0 | 27.3 |
| | 6-8 | 17 | 19.7 | 24.6 | 0.0 | 68.2 |
| | 9-11 | 2 | 1.2 | 1.7 | 0.0 | 2.4 |
| | ≥ 12 | 17 | 1.2 | 2.7 | 0.0 | 9.1 |

Appendix E4. White-tailed deer seasonal utilization of openings as related to number of openings within a 1.0 km radius, Oakwood bottoms region Shawnee National Forest.

| INDEX | Number of Openings | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| WINTER | | | | | | |
| Total trails | 0-2 | 5 | 3.8 | 2.3 | 0.0 | 6.0 |
| | 3-5 | 4 | 1.0 | 1.4 | 0.0 | 3.0 |
| Total beds | 0-2 | 5 | 1.2 | 1.6 | 0.0 | 4.0 |
| | 3-5 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| SPRING | | | | | | |
| Total trails | 0-2 | 5 | 2.8 | 2.6 | 0.0 | 6.0 |
| | 3-5 | 4 | 1.5 | 1.3 | 0.0 | 3.0 |
| Total beds | 0-2 | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 3-5 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent plots foraged | 0-2 | 5 | 2.6 | 2.6 | 0.0 | 5.9 |
| | 3-5 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| SUMMER | | | | | | |
| Total trails | 0-2 | 5 | 0.6 | 0.9 | 0.0 | 2.0 |
| | 3-5 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total beds | 0-2 | 5 | 0.2 | 0.4 | 0.0 | 1.0 |
| | 3-5 | 4 | 0.5 | 1.0 | 0.0 | 2.0 |
| Percent plots foraged | 0-2 | 5 | 8.2 | 11.4 | 0.0 | 23.5 |
| | 3-5 | 4 | 6.6 | 5.7 | 0.0 | 13.3 |
| FALL | | | | | | |
| Total trails | 0-2 | 3 | 1.3 | 1.5 | 0.0 | 3.0 |
| | 3-5 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total beds | 0-2 | 3 | 1.0 | 1.7 | 0.0 | 3.0 |
| | 3-5 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent plots foraged | 0-2 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 3-5 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |

Appendix E5. White-tailed deer seasonal utilization of openings as related to number of openings within a 1.0 km radius, southwest region Shawnee National Forest.

| INDEX | Number of Openings | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| WINTER | | | | | | |
| | 0-2 | 6 | 2.5 | 1.6 | 0.0 | 5.0 |
| | 3-5 | 9 | 2.3 | 1.8 | 0.0 | 5.0 |
| | 6-8 | 18 | 3.8 | 2.7 | 1.0 | 9.0 |
| | 9-11 | 5 | 3.8 | 2.2 | 0.0 | 5.0 |
| Total trails | ≥ 12 | 8 | 4.8 | 1.0 | 3.0 | 6.0 |
| | 0-2 | 6 | 1.5 | 1.4 | 0.0 | 3.0 |
| | 3-5 | 9 | 1.8 | 2.1 | 0.0 | 6.0 |
| | 6-8 | 18 | 1.4 | 1.6 | 0.0 | 4.0 |
| | 9-11 | 5 | 3.4 | 1.9 | 0.0 | 5.0 |
| Total beds | ≥ 12 | 8 | 2.1 | 1.8 | 0.0 | 5.0 |
| SPRING | | | | | | |
| | 0-2 | 5 | 3.2 | 0.8 | 2.0 | 4.0 |
| | 3-5 | 9 | 2.1 | 1.4 | 0.0 | 5.0 |
| | 6-8 | 18 | 3.9 | 2.9 | 0.0 | 12.0 |
| | 9-11 | 5 | 1.8 | 0.8 | 1.0 | 3.0 |
| Total trails | ≥ 12 | 8 | 6.3 | 2.9 | 3.0 | 12.0 |
| | 0-2 | 5 | 0.6 | 1.3 | 0.0 | 3.0 |
| | 3-5 | 9 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 6-8 | 18 | 0.1 | 0.2 | 0.0 | 1.0 |
| | 9-11 | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total beds | ≥ 12 | 8 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0-2 | 5 | 8.7 | 8.5 | 0.0 | 19.2 |
| | 3-5 | 9 | 1.8 | 2.5 | 0.0 | 5.4 |
| | 6-8 | 18 | 1.1 | 1.7 | 0.0 | 5.4 |
| Percent plots foraged | 9-11 | 5 | 3.8 | 3.3 | 0.0 | 8.3 |
| | ≥ 12 | 8 | 0.8 | 2.2 | 0.0 | 6.3 |
| SUMMER | | | | | | |
| | 0-2 | 6 | 1.0 | 1.1 | 0.0 | 2.0 |
| | 3-5 | 9 | 0.9 | 1.2 | 0.0 | 3.0 |
| | 6-8 | 18 | 1.2 | 1.3 | 0.0 | 4.0 |
| | 9-11 | 5 | 0.8 | 0.8 | 0.0 | 2.0 |
| Total trails | ≥ 12 | 8 | 2.1 | 1.1 | 0.0 | 4.0 |
| | 0-2 | 6 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 3-5 | 9 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 6-8 | 18 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 9-11 | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total beds | ≥ 12 | 8 | 0.3 | 0.5 | 0.0 | 1.0 |

Appendix E5. Continued.

| INDEX | Number of Openings | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|---|
| Percent plots foraged | 0-2 | 6 | 13.2 | 10.9 | 3.4 | 33.3 |
| | 3-5 | 9 | 2.8 | 4.8 | 0.0 | 14.8 |
| | 6-8 | 18 | 5.5 | 6.4 | 0.0 | 25.7 |
| | 9-11 | 5 | 9.5 | 4.6 | 4.9 | 17.0 |
| | ≥ 12 | 8 | 10.6 | 9.0 | 0.0 | 26.9 |
| FALL | | | | | | |
| Total trails | 0-2 | 6 | 0.8 | 1.0 | 0.0 | 2.0 |
| | 3-5 | 8 | 0.4 | 0.7 | 0.0 | 2.0 |
| | 6-8 | 18 | 1.8 | 1.6 | 0.0 | 5.0 |
| | 9-11 | 4 | 1.0 | 0.8 | 0.0 | 2.0 |
| | ≥ 12 | 8 | 1.3 | 1.0 | 0.0 | 3.0 |
| Total beds | 0-2 | 6 | 0.3 | 0.8 | 0.0 | 2.0 |
| | 3-5 | 8 | 0.1 | 0.4 | 0.0 | 1.0 |
| | 6-8 | 18 | 0.2 | 0.4 | 0.0 | 1.0 |
| | 9-11 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥ 12 | 8 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent plots foraged | 0-2 | 6 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 3-5 | 8 | 1.1 | 2.0 | 0.0 | 4.6 |
| | 6-8 | 18 | 3.2 | 4.2 | 0.0 | 12.8 |
| | 9-11 | 4 | 2.0 | 3.2 | 0.0 | 6.7 |
| | ≥ 12 | 8 | 4.5 | 6.1 | 0.0 | 15.0 |

[illegible]

Appendix F. Plant species foraged upon by deer in maintained forest openings in the Shawnee National Forest.

| Scientific name[1] | Common Name | No. openings in which species was foraged | | |
|---|---|---|---|---|
| | | Spring | Summer | Fall |
| ACERACEAE | | | | |
| *Acer negundo* | box elder | 1 | | |
| A. *rubrum* | red maple | | | 1 |
| ANACARDIACEAE | | | | |
| *Rhus copallina* | dwarf sumac | | 2 | 5 |
| R. *glabra* | smooth sumac | 4 | 2 | 5 |
| *Toxicodendron radicans* | poison ivy | 5 | 25 | 21 |
| APIACEAE | | | | |
| *Daucus carota* | Queen-Ann's lace | | 73 | 35 |
| APOCYNACEAE | | | | |
| *Apocynum cannabinum* | dogbane | | 2 | 1 |
| ASCLEPIADACEAE | | | | |
| *Asclepias syriaca* | common milkweed | | 2 | |
| A. *tuberosa* | butter-fly weed | | 1 | 1 |
| ASTERACEAE | | | | |
| *Achillea millefolium* | yarrow | | 1 | |
| *Ambrosia artemisiifolia* | common ragweed | | 14 | 21 |
| A. *trifida* | giant ragweed | | 2 | 1 |
| *Aster*[2] spp. | aster | 1 | 8 | |
| *Bidens aristosa* | tickseed sunflower | | 14 | 11 |
| *Boltonia asteroides* | false aster | | 6 | |
| *Cirsium*[3] spp. | thistle | 1 | 3 | |
| *Erigeron*[4] spp. | fleabane | 2 | 4 | |
| *Eupatorium* rugosum | white snakeroot | | | 1 |
| *Helianthus* spp. | sunflower | | 1 | 1 |
| *Leucanthemum vulgare* | Ox-eye-daisy | | 1 | |
| *Rudbeckia*[5] spp. | coneflower | | 12 | |
| *Solidago*[6] spp. | goldenrod | 11 | 41 | 6 |
| BALSAMINACEAE | | | | |
| *Impatiens capensis* | jewel-weed | | 3 | |
| BIGNONIACEAE | | | | |
| *Campsis radicans* | trumpet creeper | | 50 | 19 |
| CAESALPINIACEAE | | | | |
| *Cassia fasciculata* | partridge pea | | 21 | 11 |
| *Cercis canadensis* | redbud | | | 1 |
| *Gleditsia triacanthos* | honey locust | | 2 | 2 |

Appendix F. Continued.

| Scientific name[1] | Common Name | No. openings in which species was foraged | | |
|---|---|---|---|---|
| | | Spring | Summer | Fall |
| CAPRIFOLIACEAE | | | | |
| *Lonicera japonica* | Japanese honeysuckle | 82 | 11 | 75 |
| *Symphoricarpos orbiculatus* | coral berry | 1 | 3 | 2 |
| CONVOLVULACEAE | | | | |
| *Ipomoea* spp. | morning-glory | | 3 | 1 |
| CORNACEAE | | | | |
| *Cornus* spp. | dogwood | 2 | | 1 |
| CYPERACEAE | | | | |
| | unidentified sedges | 1 | 1 | |
| EBENACEAE | | | | |
| *Diospyros virginiana* | persimmon | | 9 | 8 |
| ELAEAGNACEAE | | | | |
| *Elaegnus agustifolia* | Russian olive | | | 1 |
| EUPHORBIACEAE | | | | |
| *Acalypha* spp. | three-seeded Mercury | | 1 | |
| *Euphorbia corollata* | flowering spurge | | | |
| FABACEAE | | | | |
| *Desmondium* spp. | tick trefoil | | 59 | 34 |
| *Kummerowia stipulacea* | Korean lespedeza | | 9 | 5 |
| *K. striata* | Japanese lespedeza | | 21 | 18 |
| *Lespedeza* spp. | lespedeza | | 2 | 1 |
| *Melilotus* spp. | sweet clover | 7 | 7 | 18 |
| *Robina pseudoacacia* | black locust | | | 4 |
| *Strophostyles* spp. | wild bean | | 1 | 1 |
| *Trifolium* spp. | clover | 38 | 76 | 32 |
| *Vicia* spp. | vetch | | 3 | 6 |
| *Vigna unguiculata* | cow pea | | | 14 |
| FAGACEAE | | | | |
| *Quercus* spp. | oak | 1 | 1 | |
| HYDRANGEACEAE | | | | |
| *Hydrangea arborescens* | hydrangea | | 1 | |
| JUGLANDACEAE | | | | |
| *Carya* spp. | hickory | | 1 | |
| *Juglans nigra* | black walnut | | 1 | |

Appendix F. Continued.

| Scientific name[1] | Common Name | No. openings in which species was foraged | | |
|---|---|---|---|---|
| | | Spring | Summer | Fall |
| LAMIACEAE | | | | |
| Monanda spp. | wild bergamot | | 1 | |
| Prunella vulgaris | self-heal | | 6 | 8 |
| Pycanthemum spp. | mountain mint | | 1 | 1 |
| | unidentified mints | | 4 | 3 |
| LAURACEAE | | | | |
| Sassafras albidum | sassafras | 5 | 4 | 33 |
| LILIACEAE | | | | |
| Allium canadense | wild onion | 4 | | |
| Asparagus officinalis | asparagus | | 1 | 2 |
| MAGNOLIACEAE | | | | |
| Liriodendron tulipifera | tulip tree | | | 1 |
| MORACEAE | | | | |
| Morus alba | white mulberry | | 1 | |
| NYSSACEAE | | | | |
| Nyssa sylvatica | sour gum | | 1 | |
| OLEACEAE | | | | |
| Fraxinus americana | white ash | | 8 | 10 |
| F. pennsylvanica | green ash | | 1 | |
| ONAGRACEAE | | | | |
| Ludwigia alternifolia | seedbox | | 4 | |
| Oenothera biennis | evening primrose | | | 3 |
| OXALIDACEAE | | | | |
| Oxalis dillenii | yellow wood sorrel | | | 3 |
| PASSIFLORACEAE | | | | |
| Passiflora spp. | passion flower | 1 | | |
| PHYTOLACCACEAE | | | | |
| Phytolacca americana | poke weed | | 1 | |
| PINACEAE | | | | |
| Pinus spp. | southern pine | 1 | | |

Appendix F. Continued.

| Scientific name[1] | Common Name | No. openings in which species was foraged | | |
|---|---|---|---|---|
| | | Spring | Summer | Fall |
| POACEAE | | | | |
| *Bromus* spp. | annual brome grasses | 1 | 4 | |
| *Dactylus glomerata* | orchard grass | | 3 | 1 |
| *Elymus* spp. | wild rye | | | 1 |
| *Festuca* spp. | fescue | 12 | 31 | 21 |
| *Panicum* spp. | panic grass | | 2 | 3 |
| *Phleum pratense* | timothy | | 2 | |
| *Sorghum vulgare* | milo | | 1 | 2 |
| *Tridens flavus* | purple top | | 1 | |
| *Triticum aestivum* | winter wheat | 14 | | |
| | millet | | 1 | 8 |
| | unidentified grass | 10 | 56 | 35 |
| POLYGONACEAE | | | | |
| *Fagopyrum esculentum* | buckwheat | | | 14 |
| *Polygonum* spp. | smartweed | | 1 | |
| PRIMULACEAE | | | | |
| *Lysimachia ciliata* | fringed loosestrife | | 1 | |
| RANNUNCULACEAE | | | | |
| *Anemone* spp. | anemone | | 1 | |
| ROSEACEAE | | | | |
| *Fragaria virginiana* | wild strawberry | 2 | | |
| *Potentilla simplex* | common cinquefoil | 4 | 6 | 4 |
| *Prunus* spp. | cherry | 2 | 1 | 1 |
| *Rosa*[8] spp. | rose | 39 | 24 | 25 |
| *Rubus* spp. | blackberry | 72 | 52 | 108 |
| SMILACACEAE | | | | |
| *Smilax* spp. | catbrier | | 6 | 14 |
| SOLANACEAE | | | | |
| *Physalis* spp. | ground cherry | | 2 | 2 |
| ULMACEAE | | | | |
| *Ulmus alata* | winged elm | 1 | 4 | |
| URTICACEAE | | | | |
| *Boehmeria cylindrica* | false nettle | | 1 | |
| VERBENACEAE | | | | |
| *Verbena urticifolia* | white vervain | | 1 | |

Appendix F. Continued.

| Scientific name[1] | Common Name | No. openings in which species was foraged<br>Spring | Summer | Fall |
|---|---|---|---|---|
| VITACEAE | | | | |
| *Parthenocissus quinquefolia* | Virginia creeper | | | 1 |
| *Vitis* spp. | grape | 4 | 42 | 22 |

[1] Nomenclature of plants conforms to Schery (1972) and Mohlenbrock (1986).

[2] Primarily *Aster pilosus* (hairy aster)

[3] Primarily *Cirsium vulgare* (rosettes of bull thistle)

[4] Primarily *Erigeron annuus* (daisy fleabane)

[5] Primarily *Rudbeckia triloba* and R. *hirta* (brown and black-eyed Susan)

[6] Primarily *Solidago nemoralis* (field goldenrod)

[7] Primarily *Trifolium pratense* and T. *repens f. lodigense* (red and ladino clover)

[8] Primarily *Rosa multiflora* and R. *carolina* (multiflora and pasture rose)

Appendix G. Variation in breeding bird abundance in various size (ha) openings and within transect segments running away from openings located in mature deciduous habitat in the Shawnee National Forest.

| Variable | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|
| | | 0.1-0.2 ha openings | | | |
| WITHIN | | | | | |
| $\bar{x}$ species | 4 | 0.4 | 0.5 | 0.0 | 1.0 |
| $\bar{x}$ individuals | 4 | 0.6 | 0.7 | 0.0 | 1.3 |
| 0-25 m | | | | | |
| $\bar{x}$ species | 4 | 2.7 | 0.8 | 2.0 | 3.7 |
| $\bar{x}$ individuals | 4 | 4.0 | 1.2 | 2.7 | 5.3 |
| 25-50 m | | | | | |
| $\bar{x}$ species | 4 | 2.3 | 2.1 | 0.3 | 5.0 |
| $\bar{x}$ individuals | 4 | 2.3 | 2.1 | 0.3 | 5.0 |
| 50-75 m | | | | | |
| $\bar{x}$ species | 4 | 2.2 | 1.2 | 1.0 | 3.3 |
| $\bar{x}$ individuals | 4 | 2.4 | 1.3 | 1.3 | 3.7 |
| 75-100 m | | | | | |
| $\bar{x}$ species | 4 | 2.6 | 1.5 | 1.3 | 4.3 |
| $\bar{x}$ individuals | 4 | 2.7 | 1.4 | 1.3 | 4.3 |
| | | 0.3-0.6 ha openings | | | |
| WITHIN | | | | | |
| $\bar{x}$ species | 11 | 2.0 | 1.3 | 0.3 | 4.0 |
| $\bar{x}$ individuals | 11 | 2.5 | 1.7 | 0.7 | 6.3 |
| 0-25 m | | | | | |
| $\bar{x}$ species | 11 | 3.9 | 2.0 | 1.0 | 7.7 |
| $\bar{x}$ individuals | 11 | 4.7 | 2.3 | 1.0 | 9.0 |
| 25-50 m | | | | | |
| $\bar{x}$ species | 11 | 2.7 | 0.9 | 1.7 | 4.3 |
| $\bar{x}$ individuals | 11 | 3.0 | 1.1 | 1.7 | 4.7 |
| 50-75 m | | | | | |
| $\bar{x}$ species | 11 | 2.6 | 1.1 | 1.0 | 4.3 |
| $\bar{x}$ individuals | 11 | 2.9 | 1.4 | 1.0 | 5.7 |
| 75-100 m | | | | | |
| $\bar{x}$ species | 11 | 2.1 | 1.3 | 0.3 | 5.0 |
| $\bar{x}$ individuals | 11 | 2.3 | 1.5 | 0.3 | 5.7 |

Appendix G. Continued.

| Variable | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|
| | | 0.7-1.0 ha | | | |
| WITHIN | | | | | |
| $\bar{x}$ species | 6 | 3.3 | 1.7 | 2.0 | 6.7 |
| $\bar{x}$ individuals | 6 | 5.0 | 2.8 | 2.0 | 10.0 |
| 0-25 m | | | | | |
| $\bar{x}$ species | 6 | 4.0 | 1.9 | 1.7 | 6.3 |
| $\bar{x}$ individuals | 6 | 5.5 | 2.9 | 2.0 | 9.0 |
| 25-50 m | | | | | |
| $\bar{x}$ species | 6 | 2.6 | 1.5 | 0.7 | 5.0 |
| $\bar{x}$ individuals | 6 | 2.8 | 1.5 | 0.7 | 5.0 |
| 50-75 m | | | | | |
| $\bar{x}$ species | 6 | 2.4 | 0.6 | 1.3 | 3.0 |
| $\bar{x}$ individuals | 6 | 2.6 | 0.6 | 1.7 | 3.3 |
| 75-100 m | | | | | |
| $\bar{x}$ species | 6 | 2.7 | 1.3 | 1.3 | 4.3 |
| $\bar{x}$ individuals | 6 | 3.0 | 1.4 | 1.7 | 5.0 |

Appendix H. Variation in breeding bird abundance in various size (ha) openings and within transect segments running away from openings through southern pine stands of varying structure, Shawnee National Forest.

| Variable | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|
| | | 0.1-0.2 ha openings[1] | | | |
| WITHIN | | | | | |
| $\bar{x}$ species | 2 | 1.0 | 1.4 | 0.0 | 2.0 |
| $\bar{x}$ individuals | 2 | 1.9 | 2.6 | 0.0 | 3.7 |
| 0-25 m | | | | | |
| $\bar{x}$ species | 2 | 2.2 | 0.2 | 2.0 | 2.3 |
| $\bar{x}$ individuals | 2 | 2.7 | 0.9 | 2.0 | 3.3 |
| 25-50 m | | | | | |
| $\bar{x}$ species | 2 | 0.5 | 0.3 | 0.3 | 0.7 |
| $\bar{x}$ individuals | 2 | 0.9 | 0.2 | 0.7 | 1.0 |
| 50-75 m | | | | | |
| $\bar{x}$ species | 2 | 1.0 | 1.4 | 0.0 | 2.0 |
| $\bar{x}$ individuals | 2 | 1.0 | 1.4 | 0.0 | 2.0 |
| 75-100 m | | | | | |
| $\bar{x}$ species | 2 | 1.2 | 0.2 | 1.0 | 1.3 |
| $\bar{x}$ individuals | 2 | 1.2 | 0.2 | 1.0 | 1.3 |
| | | 0.1-0.2 ha openings[2] | | | |
| WITHIN | | | | | |
| $\bar{x}$ species | 2 | 0.5 | 0.7 | 0.0 | 1.0 |
| $\bar{x}$ individuals | 2 | 0.9 | 1.2 | 0.0 | 1.7 |
| 0-25 m | | | | | |
| $\bar{x}$ species | 2 | 3.0 | 0.0 | 3.0 | 3.0 |
| $\bar{x}$ individuals | 2 | 3.9 | 1.2 | 3.0 | 4.7 |
| 25-50 m | | | | | |
| $\bar{x}$ species | 2 | 2.4 | 0.5 | 2.0 | 2.7 |
| $\bar{x}$ individuals | 2 | 2.5 | 0.3 | 2.3 | 2.7 |
| 50-75 m | | | | | |
| $\bar{x}$ species | 2 | 1.9 | 1.2 | 1.0 | 2.7 |
| $\bar{x}$ individuals | 2 | 2.0 | 1.0 | 1.3 | 2.7 |
| 75-100 m | | | | | |
| $\bar{x}$ species | 2 | 2.9 | 1.6 | 1.7 | 4.0 |
| $\bar{x}$ individuals | 2 | 3.0 | 0.0 | 3.0 | 3.0 |

Appendix H. Continued.

| Variable | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|
| | | 0.3-0.6 ha openings[3] | | | |
| WITHIN | | | | | |
| $\bar{x}$ species | 8 | 0.2 | 0.3 | 0.0 | 0.7 |
| $\bar{x}$ individuals | 8 | 0.2 | 0.3 | 0.0 | 0.7 |
| 0-25 m | | | | | |
| $\bar{x}$ species | 8 | 2.2 | 0.7 | 1.0 | 3.0 |
| $\bar{x}$ individuals | 8 | 2.6 | 0.8 | 1.7 | 3.7 |
| 25-50 m | | | | | |
| $\bar{x}$ species | 8 | 1.2 | 0.4 | 0.7 | 1.7 |
| $\bar{x}$ individuals | 8 | 1.2 | 0.5 | 0.7 | 1.7 |
| 50-75 m | | | | | |
| $\bar{x}$ species | 8 | 0.9 | 0.5 | 0.3 | 1.7 |
| $\bar{x}$ individuals | 8 | 1.1 | 0.5 | 0.3 | 1.7 |
| 75-100 m | | | | | |
| $\bar{x}$ species | 8 | 0.9 | 0.7 | 0.0 | 2.0 |
| $\bar{x}$ individuals | 8 | 0.9 | 0.7 | 0.0 | 2.0 |
| | | 0.3-0.6 ha openings[4] | | | |
| WITHIN | | | | | |
| $\bar{x}$ species | 5 | 1.7 | 1.4 | 0.0 | 3.3 |
| $\bar{x}$ individuals | 5 | 2.3 | 1.9 | 0.0 | 4.7 |
| 0-25 m | | | | | |
| $\bar{x}$ species | 5 | 3.7 | 1.3 | 2.3 | 5.7 |
| $\bar{x}$ individuals | 5 | 4.7 | 1.0 | 3.7 | 6.3 |
| 25-50 m | | | | | |
| $\bar{x}$ species | 5 | 2.9 | 0.4 | 2.3 | 3.3 |
| $\bar{x}$ individuals | 5 | 3.3 | 0.9 | 2.3 | 4.7 |
| 50-75 m | | | | | |
| $\bar{x}$ species | 5 | 2.7 | 0.9 | 2.0 | 4.0 |
| $\bar{x}$ individuals | 5 | 2.8 | 1.0 | 2.0 | 4.3 |
| 75-100 m | | | | | |
| $\bar{x}$ species | 5 | 2.3 | 1.2 | 0.3 | 3.3 |
| $\bar{x}$ individuals | 5 | 2.6 | 1.3 | 0.3 | 3.3 |

Appendix H. Continued.

| Variable | N | $\bar{X}$ | S.D. | MIN | MAX |
|---|---|---|---|---|---|
| | | 0.3-0.6 ha openings[5] | | | |
| WITHIN | | | | | |
| $\bar{x}$ species | 3 | 2.0 | 1.9 | 0.3 | 4.0 |
| $\bar{x}$ individuals | 3 | 2.1 | 1.9 | 0.3 | 4.0 |
| 0-25 m | | | | | |
| $\bar{x}$ species | 3 | 4.3 | 2.2 | 2.3 | 6.7 |
| $\bar{x}$ individuals | 3 | 5.1 | 2.4 | 2.6 | 7.3 |
| 25-50 m | | | | | |
| $\bar{x}$ species | 3 | 1.9 | 1.0 | 1.0 | 3.0 |
| $\bar{x}$ individuals | 3 | 2.7 | 1.5 | 1.0 | 4.0 |
| 50-75 m | | | | | |
| $\bar{x}$ species | 3 | 1.6 | 0.6 | 1.3 | 2.3 |
| $\bar{x}$ individuals | 3 | 2.1 | 0.7 | 1.3 | 2.7 |
| 75-100 m | | | | | |
| $\bar{x}$ species | 3 | 2.2 | 1.7 | 0.3 | 3.3 |
| $\bar{x}$ individuals | 3 | 2.3 | 1.7 | 0.3 | 3.3 |

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[1] Canopy coverage 0.6 m - 7.5 m = 54%, >7.5 m = 55%.

[2] Canopy coverage 0.6 m - 7.5 m = 35%, >7.5 m = 49%.

[3] Unmanaged, canopy coverage 0.6 m - 7.5 m = 64%, >7.5 m = 60%.

[4] Managed, canopy coverage 0.6 m - 7.5 m = 24%, >7.5 m = 25%.

[5] Canopy coverage 0.6 m - 7.5 m = 25%, >7.5 m = 59%.